EMMETT STULL GOFF,
Professor of Horticulture, University of Wisconsin, 1893-1902, born at Elmira, N. Y., September 3, 1852, died at Madison, Wis., June 6, 1902.

NINETEENTH ANNUAL REPORT

OF THE

Agricultural Experiment Station

OF THE

UNIVERSITY OF WISCONSIN

For the year ending June 30, 1902.

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☞ **The Bulletins and Annual Reports of this Station are sent free to all residents of the State upon request.**

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Dairy Building and Joint Horticulture-Physics Building, west end of Observatory Hill, adjacent to Horticultural Grounds and Experiment Farm.

Telephone to Station Office, Dairy Building and Farm Office.

LETTER OF TRANSMITTAL.

MÉNOMONIE, WIS., DECEMBER 1st, 1902.

To his Excellency, ROBERT M. LA FOLLETTE,

Governor of Wisconsin:

I have the honor to transmit to you herewith, in accordance with law, the Nineteenth Annual Report of the Agricultural Experiment Station of the University of Wisconsin.

Respectfully,

JAMES H. STOUT,

President of the Board of Regents.

REPORT OF THE DIRECTOR.

In this the nineteenth annual report of the Wisconsin Agricultural Experiment Station we have followed our custom of reporting some of our experimental work reaching down to nearly the date of going to press, October 1, 1902. The fiscal year of the Experiment Station closed June 30, 1902, and our accounting for government funds expended covers the year ending at that time.

The Central Agricultural College Building.—The legislature of 1901 generously appropriated to the University of Wisconsin $150,000 for the construction of a central building for the College of Agriculture. It was understood that the sum so appropriated should be used entirely for the construction of the building and that the furnishings—desks, tables, shelving and other equipment—should be provided by a subsequent legislature. The building was planned by University Architect J. T. W. Jennings after a careful consideration of the needs of both the College of Agriculture and the Experiment Station. Mr. Jennings and the writer visited and studied the architecture and construction of the buildings at the following universities: Harvard, Yale, New York, Columbia, Rutgers, Princeton, Philadelphia, Syracuse, Cornell, Ohio, Illinois, and Northwestern. It was finally decided that our requirements would best be met by the erection of a structure in the renaissance style of architecture of Bedford limestone and buff pressed brick with red Spanish tile roof. The building is 200 feet in length by 64 in depth, and four stories in height. At the rear and connected with the main structure is an octagon 66 feet in diameter, two stories in height, the first floor of which is for library and reading room purposes, the second forming an auditorium with 750

seats. In the main structure are rooms for the following departments: executive, agricultural chemistry, agricultural bacteriology, animal husbandry, farm crops and farmers' institute, which departments are now in existence in this college, with provisions for future departments of economic entomology, vegetable pathology and forestry. At the time of writing, the roof is being placed on the building. Owing to the absence of furniture and equipment, the date at which the building will be in use cannot be stated at this time. We believe that in appearance, proportions and appointments this structure will prove satisfactory not only to those who are to use it as investigators, teachers and pupils, but also to our farmer constituents, largely through whose influence it was secured. In our new agricultural hall we have a structure which should stand for ages as in some fair measure representative of the intelligence, earnestness and ambition of the agricultural people of Wisconsin at the beginning of the twentieth century.

Changes in the Station Staff.—It is with regret that a number of changes in our Station staff for the year now closing must be here reported. Prof. E. S. Goff was taken from us by death, June 6, 1902. In another place appears a brief tribute to our cherished associate and co-worker. The position of horticulturist of the Station and professor of horticulture in the college, made vacant by the death of Professor Goff, has been filled by Mr. E. P. Sandsten, at the time of his election associate professor of horticulture, Maryland Agricultural College.

Mr. Sandsten was born in Sweden thirty-five years ago and was graduated from the high school in his native country. He served as a market gardener in St. Paul for two years, and in 1887 entered the Minnesota School of Agriculture, completing the three-years' course. He then entered the long course in agriculture at the University of Minnesota and was graduated therefrom in June, 1895. While a student he served as editor of "The Market Garden." Upon graduation he was appointed gardener and farmer of the Minnesota State Training (Reform) School at Redmond, where for three years he had charge of a garden and farm of 480 acres. In 1897 he was given the M. S. degree by the University of Minnesota. After serving in other

positions he entered the Cornell university in the fall of 1900, and is at this writing completing his work for the Ph. D. degree, his major subject being horticulture, with forestry and agricultural chemistry as minor subjects. In July, 1901, he was elected assistant in horticulture in the Maryland Agricultural college, and this year was made associate professor of horticulture in that institution. Professor Sandsten will take up his work with us October first.

Mr. Alfred Vivian, assistant in agricultural chemistry, resigned in August of the present year to take the chair of assistant professor of agricultural chemistry in the Ohio State university. Mr. Vivian was an efficient, careful worker in our Station, and an excellent teacher in agricultural chemistry. The best wishes of all his associates and former students follow him to his advanced position.

Mr. Vivian has been temporarily succeeded by Mr. John Clarence Brown. Mr. Brown was graduated in the agricultural course at the Iowa State college in 1899, and received the M. S. degree from that institution in 1900, where he had served as instructor in agricultural chemistry. At the time of his appointment he was pursuing studies in agricultural chemistry with us, leading to the degree of Ph. D.

In our last report was announced the withdrawal from the Station force of Prof. F. H. King, who for many years had so ably conducted the department of agricultural physics. Assistant Professor Whitson, who had served under Professor King, was advanced to the position thus made vacant, and in turn his place was filled by the advancement of Mr. F. J. Wells, under the title of instructor in agricultural physics. Mr. Wells is a graduate of the Oshkosh normal school and Lawrence university. He resigned the principalship of the De Pere public schools to pursue studies with us.

Mr. E. G. Hastings, who has been pursuing advanced studies in Germany for the past year, returns to again take up his work of assistant bacteriologist to the Station.

Fertilizer and Feeding-stuffs Control Laws.—In 1895 the legislature passed a law regulating the analysis and sale of commercial fertilizers. The execution of the law was placed with

the Experiment Station. For each and every brand of fertilizers sold in the state at a price of more than $10 per ton, the manufacturer must pay annually to the Experiment Station a license fee of $25. The purpose of this law was to protect purchasers against fraudulent fertilizers.

The legislature of 1901 enacted a similar law in reference to concentrated commercial feeding stuffs. Copies of both these laws will be found on the last pages of this report. The carrying out of these laws places a considerable burden on the Station, especially in the way of collecting samples, analyzing the same, etc. The work has been placed in direct charge of Professor Woll. To aid him in conducting the analyses, etc., Mr. Geo. A. Olson has been appointed assistant in chemistry. Besides helping in the line of feeding stuffs and fertilizers he will assist in other laboratory work. Mr. Olson was graduated from the agricultural course in this college, June, 1902.

Improvements at the Farm.—At the time of writing this report road construction is in active progress at the farm, under the direction of Farm Superintendent Adams. Macadam road is being built from the marsh bridge easterly along the lakeshore drive and southward to the horse barn and thence to the west end of Linden drive. This improvement was sorely needed and comes none too soon. Following this work a large amount of cement sidewalk will be constructed. There will yet remain the macadamizing of the east end of Linden drive, all of the dean's drive and a highway down Observatory hill slope to join the last named. This with the road-building and landscaping of the grounds about our new agricultural hall will no doubt occupy our attention and all our spare funds for some two or three years to come.

All of the college buildings, excepting the horse barn, recently constructed, are being painted, and all are being put in good condition.

At the Hill farm we have finished removing the timber from about fifteen acres of land which tract is this year for the first time in farm crops. New fences of the most stable character have replaced all of the old ones, and many other improvements have been made. This farm, which is now in very satisfactory

condition, is proving a great aid in our work, but we still need additional farming lands.

Department of Farm Crops.—This new department, provided for by our last legislature, is proving a most valuable adjunct, both as to experiments and instruction. Mr. Moore has taken up several varieties of farm plants which promise to be of great importance to our farmers. Notable among these is a variety of oats introduced through the Department of Agriculture, Washington, D. C. It now looks as though we would be able to increase the yield of oats on Wisconsin farms by several bushels per acre through the introduction of this variety. Experiments with the soy bean, a legume introduced from Japan, are also in progress, promising excellent returns.

The Cold Curing of Cheese.—The investigations of Doctor Babcock and Doctor Russell in relation to what transpires in the curing of cheese, while originally of a purely scientific character, are now leading to intensely practical results. Our own experiments in the cold curing of cheese as planned by these investigators have met with the highest success, and the Canadian government has taken up the matter actively. At least one cheese company in Wisconsin is building factories which have no cheese-curing rooms whatever connected with them, the whole product of the factories being shipped as soon as made to central quarters where it can be cured at low temperatures. A joint experiment is now being undertaken by the U. S. Department of Agriculture, Washington, and this Station, to further test the merits of this form of ripening cheese.

Publications.—During the year ending June 30th, 1902, the Experiment Station issued the following publications:

Bulletin No. 88	5,000 copies,	11 pages each,	55,000 total pages.
Bulletin No. 89	14,000 copies,	8 pages each,	112,000 total pages.
Bulletin No. 90	16,000 copies,	8 pages each,	128,000 total pages.
Bulletin No. 91	50,000 copies,	15 pages each,	750,000 total pages.
Bulletin No. 92	14,000 copies,	20 pages each,	280,000 total pages.
Bulletin No. 93	4,000 copies,	39 pages each,	156,000 total pages.
Totals	103,000 copies	101 pages	1,471,000 total pages.
Annual report	15,000 copies,	352 pages each,	5,280,000 total pages.
Total page reports and bulletins			6,751,000

The above shows that during the year there were published by the Station six bulletins and an annual report, containing

in all 453 pages of printed matter, prepared by the workers of the Station. During the year 6,751,000 pages of printed matter in the form of reports and bulletins were distributed from the Station, nearly all going to the farmers of Wisconsin. Numerous newspaper bulletins on various agricultural subjects were also sent to all the papers in the state as well as the agricultural press generally.

Available publications.—Most of our earlier publications are now out of print. We have on hand and will supply to residents of this state only, upon request, until exhausted, any of the following:

Thirteenth Annual Report for the year 1896.
Fourteenth Annual Report for the year 1897.
Fifteenth Annual Report for the year 1898.
Sixteenth Annual Report for the year 1899.
Seventeenth Annual Report for the year 1900.
Eighteenth Annual Report for the year 1901.
Bulletin No. 28. The Construction of Silos. July, 1891.
Bulletin No. 29. Creaming Experiments. October, 1891.
Bulletin No. 32. Feeding Grain to Lambs. July, 1892.
Bulletin No 35. Insects and Diseases Injurious to Cranberries. April, 1893.
Bulletin No. 37. The Russian Thistle. October, 1893.
Bulletin No. 41. Grain Feeding Lambs for Market. August, 1894.
Bulletin No. 42. Destructive Effects of Winds on Sandy Soils and Light Sandy Loams, With Methods of Protection. October, 1894.
Bulletin No. 43. The Agricultural, Horticultural and Live-Stock Features of a Portion of Wisconsin Tributary to Superior. January, 1895.
Bulletin No. 46. Power Tests of Centrifugal Cream Separators. October, 1895.
Bulletin No. 48. The Conn Culture (B41) in Butter Making. January, 1896.
Bulletin No. 52. A Comparison of the Babcock Test and the Gravimetric Method of Estimating Fat in Skim Milk. The Alkaline Tablet Test of Acidity in Milk or Cream. July, 1896.
Bulletin No. 53. Analyses of Licensed Commercial Fertilizers. July, 1896.
Bulletin No. 55. Beet Sugar Production: Possibilities for a New Industry in Wisconsin. December, 1896.

Bulletin No. 60. The Cheese Industry: Its Development and Possibilities in Wisconsin. May, 1897.

Bulletin No. 61. The Constitution of Milk with Especial Reference to Cheese Production. September, 1897.

Bulletin No. 62. Tainted or Defective Milks: Their Causes and Methods of Prevention. September, 1897.

Bulletin No. 63. The Culture of Native Plums in the Northwest. October, 1897.

Bulletin No. 64. Sugar Beet Investigations in Wisconsin During 1897. January, 1898.

Bulletin No. 65. A Bacterial Rot of Cabbage and Allied Plants. February, 1898.

Bulletin No. 66. Analyses of Licensed Commercial Fertilizers. April, 1898.

Bulletin No. 67. Factory Tests for Milk. June, 1898.

Bulletin No. 68. One Year's Work Done by a 16-Foot Geared Windmill. June, 1898.

Bulletin No. 70. Construction of Cheese Curing Rooms for Maintaining Temperatures of 58 degrees to 68 degrees F. January, 1899.

Bulletin No. 71. Sugar Beet Investigations in Wisconsin During 1898. February, 1899.

Bulletin No. 72. Small Fruits in 1898. April, 1899.

Bulletin No. 73. Analyses of Licensed Commercial Fertilizers, 1899. April, 1899.

Bulletin No. 75. Testing Cows at the Farm. October, 1899.

Bulletin No. 76. Noxious Weeds of Wisconsin. July, 1899.

Bulletin No. 77. Effects of the February Freeze of 1899 upon Nurseries and Fruit Plantations in the Northwest. August, 1899.

Bulletin No. 78. The History of a Tuberculous Herd of Cows. August, 1899.

Bulletin No. 79. Principles of Construction and Maintenance of Country Roads. September, 1899.

Bulletin No. 80. The Character and Treatment of Swamp or Humus Soil. January, 1900.

Bulletin No. 81. Analyses of Licensed Commercial Fertilizers, 1900. April, 1900.

Bulletin No. 82. Experiments in Grinding with Small Steel Feed Mills. April, 1900.

Buletin No. 83. Silage, and the Construction of Modern Silos. May, 1900.

Bulletin No. 84. Bovine Tuberculosis in Wisconsin. March, 1901.

Bulletin No. 85. Development and Distribution of Nitrates and Other Soluble Salts in Cultivated Soils. March, 1901.

Bulletin No. 86. Analyses of Licensed Commercial Fertilizers. March, 1901.

Bulletin No. 87. Native Plums. April, 1901.

Bulletin No. 88. Dairy Industry in Wisconsin. September, 1901.

Bulletin No. 89. The Law Regulating the Sale and Analysis of Concentrated Feeding Stuffs in Wisconsin. November, 1901.

Bulletin No. 90. Concentrated Feeding Stuffs and Fertilizers Licensed for Sale in Wisconsin, 1902. January, 1902.

Bulletin No. 91. Oat Smut in Wisconsin. February, 1902.

Bulletin No. 92. Licensed Commercial Fertilizers and Concentrated Feeding Stuffs, 1902. April, 1902.

Bulletin No. 93. Development and Distribution of Nitrates in Cultivated Soils. May, 1902.

Bulletin No. 94. Curing of Cheddar Cheese with Especial Reference to Cold-curing. August, 1902.

Bulletin No. 95. Some Observations on Sheep Breeding from the Experiment Station Flock Records. August, 1902.

Bulletin No. 96. Investigations of Methods of Milking. September, 1902.

Special Bulletins. The Prevention of Oat Smut. March, 1901.

Special Bulletin. Canker Sore Mouth in Young Pigs. May, 1901.

Special Bulletin. Directions for Growing and Feeding Rape. May, 1901.

Reports and Bulletins Wanted.—We have many calls from public libraries and from colleges and experiment stations for copies of former reports and bulletins. The following are out of print and very much desired: Annual reports of the Agricultural Experiment Station, I and IV; Bulletins of the Agricultural Experiment Station (not Farmers' Institute), 1 to 11, inclusive; also 13 and 15.

Friends of the Station who are not keeping files of our publications are earnestly urged to return to us any copies they may have of the rare reports and bulletins. We will gladly pay a reasonable sum for any of the lacking numbers above noted. Readers should bear in mind that the documents asked for are Experiment Station bulletins and reports, and not bulletins of the Farmers' Institutes, which is another branch of the Agricultural College.

In Memoriam.

EMMETT STULL GOFF, born at Elmira, N. Y., September 3, 1852, died at Madison, Wis., June 6, 1902.

Professor Goff's scholastic education was obtained in the common schools of New York and at the Elmira Free Academy, from which he was graduated in 1869. His work as a student, however, continued to the day of his death. By his own exertions he had become a fair scholar in French, and was a most excellent, systematic botanist. For several years he was horticulturist of the New York Experiment Station, Geneva. In 1889 he was elected to the chair of Horticulture in the University of Wisconsin. To Professor Goff is due a full share of credit for the upbuilding of the College of Agriculture, University of Wisconsin, and the Wisconsin Agricultural Experiment Station. As an investigator Professor Goff was original and ingenious, always persistent and deeply in earnest in his undertakings. His best single work was his study carried on here and at the University of Chicago on the "time and manner of the formation of flower buds in fruit trees." The records of his numerous investigations are found in the several annual reports of the New York Experiment Station and the last twelve reports and various bulletins of this institution.

As a teacher, Professor Goff was methodical and orderly to the last degree. Indeed, there was so much order and system in his instruction that it often annoyed shallow-minded students who could not brook restraint and direction. His mind was always on the basic principles of the subjects taught. He tried to lead his pupils normally and steadily forward in their work. There was little or no flash in his instructional methods but there was clearness of purpose and earnestness of presentation which made up for possible lack of brilliancy. As an associate Professor Goff was always considerate of the rights and welfare of others with whom he labored. During the last years of his life his health was delicate and he often toiled beyond his strength.

In addition to his efforts as an investigator and teacher Professor Goff aided faithfully in horticultural meetings, farmers' institutes and other public gatherings. Books written by him are, "Lessons in Fruit Growing," "Lessons in Pomology," and "Principles of Plant Culture." The latter work, a model of its kind, has been adopted as a text-book in a number of Agricultural Colleges and other educational institutions. There will be published by his executors a work on which he was engaged at the time of his death, entitled "First Lessons in Agriculture."

As the first horticulturist of the University of Wisconsin, Professor Goff made a success of his work and left a record which it will be hard for any successor to equal.

W. A. HENRY.

WHOLE CORN COMPARED WITH CORN MEAL FOR FATTENING PIGS.

W. A. HENRY.

The six preceding reports of this Station have each contained from one to two experiments relative to the merits of whole corn and ground corn as a food for fattening swine. Beginning in 1896 and each year since a bunch of hogs has been divided into two equal lots, one lot getting whole corn and wheat middlings, while the second lot received corn meal and wheat middlings. Records were kept of feed consumed, gains made, etc., as shown in the various reports. The trials here reported were with younger pigs than were formerly fed, as we deemed it advisable to ascertain the effects of feeding whole and ground corn on animals of this class. The age, sex and breeding of the pigs used in these trials is given in the following table:

Table showing age, sex and breeding of pigs used in whole-corn versus corn-meal experiments.

No. of Animal.	Age at beginning of trial.	Sex.	Breeding.
FIRST TRIAL.	Days.		
Lot I.— Whole corn.			
Pig No. 1	134	Barrow	Poland-China Razor-back.
Pig No. 2	115	Sow	Berkshire Razor-back.
Pig No. 3	115	Sow	Berkshire Razor-back.
Pig No. 4	146	Barrow	Razor-back.
Pig No. 5	149	Sow	Razor-back.
Pig No. 6	146	Sow	Razor-back.
Lot II.— Corn meal.			
Pig No. 1	121	Sow	Berkshire Razor-back.
Pig No. 2	134	Sow	Poland-China Razor-back.
Pig No. 3	124	Sow	Poland-China Razor-back.
Pig No. 4	146	Barrow	Razor-back.
Pig No. 5	149	Sow	Razor-back.
Pig No. 6	149	Sow	Razor-back.
SECOND TRIAL.			
Lot I.—Whole corn.			
Pig No. 1	216	Sow	Poland-China.
Pig No. 2	194	Barrow	Berkshire.
Pig No. 3	197	Barrow	Poland-China.
Lot II.—Corn meal.			
Pig No. 1	217	Sow	Poland-China.
Pig No. 2	192	Sow	Berkshire.
Pig No. 3	197	Barrow	Poland-China.

The pigs designated "Razorback" were descendants from Indian Territory feral or "wild hogs," as they are usually termed, that are being used in certain breeding experiments at the Station. In some of the experiments we have crossed the Indian Territory hogs upon Berkshires and Poland-Chinas, and some of the pigs so bred were used in the experiments. The first trial was begun August 24th, at which time the pigs were quite young. Their previous feed had been wheat middlings and ear corn. All were in a thrifty condition. The first week of the trial was regarded as preliminary and is omitted from this report.

In these trials it was deemed advisable to feed half corn and half wheat middlings, as the animals were young and needed the protein and ash of the middlings to make satisfactory bone and muscle. The pigs getting ground corn were supplied with a mixture of corn meal and middlings made into slop and fed in an ordinary trough. For those getting whole corn and wheat middlings, the corn was scattered on the ground, while the middlings were fed separately as a slop in the trough. As long as the weather was favorable the pigs were kept in a pasture field in pens several rods square. Later they were kept in small pens in the hog house. The corn used in this experiment was No. 3 Wisconsin old yellow corn. It was ground at the University farm to the following fineness:

4.2 per cent. of the meal did not pass through a screen having 8 meshes to the inch.
6.7 per cent. of the meal did not pass through a screen having 10 meshes to the inch.
53.7 per cent. of the meal did not pass through a screen having 16 meshes to the inch.
35.4 per cent. of the meal passed through a screen having 16 meshes to the inch.

After the experiment was begun some of the pigs in one lot under trial did not thrive and it was given up for a time and started again later in the season. This is the one marked "second trial" which began October 19th, lasting thirteen weeks. The following tables give the data of the trials:

Table showing results of feeding whole corn in comparison with corn meal to young growing pigs — First trial — Lot I, fed whole corn.

	PEN I.					PEN III.				
	Feed eaten.	1 B*	2 S	3 S	Total	Feed eaten.	4 B	5 S	6 S	Total
Weight at beginning, Aug. 24	Lbs.	Lbs 80	Lbs. 67	Lbs. 64	Lbs. 214	Lbs.	Lbs. 75	Lbs. 89	Lbs. 76	Lbs. 240
Feed and gain:										
1st week	71	5	3	5	13	72	2	3	2	7
2d week	61.9	1	6	3	10	66	2	4	3	9
3d week	70.2	9	8	6	23	56.9	3	5	6	14
4th week	80	2	3	5	10	75 3	4	2	1	7
5th week	80	8	7	8	23	64.2	8	7	5	20
6th week	79	6	4	5	15	71.2	−1	1	4	4
7th week	82.2	3	6	4	13	70	6	9	6	21
8th week	92.5	12	14	15	41	76.1	5	8	10	23
9th week	98.9	9	10	13	32	85	5	9	8	22
10th week	102.2	3	6	7	16	93.1	4	5	6	15
11th week	100	7	6	8	21	82.1	2	4	6	12
12th week	120.5	5	7	5	17	92.3	1	11	3	15
Final weight	....	150	147	148	448	....	116	157	136	409
Feed eaten and gains.	1038.4	70	80	84	234	904.2	41	68	60	169

* B = Barrow. S = Sow.

Table showing results of feeding whole corn and corn meal to young growing pigs — First trial — Lot II, fed ground corn and middlings.

	FEED EATEN.	PEN II.				FEED EATEN.	PEN IV.			
	Ground corn and middlings.	1 S*	2 S	3 S	Total	Ground corn and middlings.	4 B	5 S	6 S	Total
Weight at beginning, Aug. 24....	Lbs.	Lbs 65	Lbs. 86	Lbs. 65	Lbs. 216	Lbs.	Lbs. 64	Lbs. 80	Lbs. 96	Lbs. 240
Feed and gain:										
1st week.....	74.4	5	2	4	11	70.4	4	5	7	16
2d week.....	72 0	4	6	......	10	77.8	1	3	5	9
3d week.....	75.5	7	4	7	18	79.0	4	6	7	17
4th week.....	74.8	5	4	2	11	69.6	1	3	5	9
5th week....	67.8	8	6	7	21	74.6	4	2	6	12
6th week..	70.0	3	2	2	7	67.8	—1	2	2	3
7th week.....	72.0	3	2	1	6	74.0	1	4	5	10
8th week.....	76.0	18	10	15	43	86.2	11	11	10	32
9th week.....	85.0	13	8	11	32	85.0	7	7	7	21
10th week...	95.0	7	6	6	19	88 0	......	11	18	29
11th week.....	112.0	10	10	9	29	92.6	3	3	—1	5
12th week.....	104.0	6	4	1	11	96.0	1	1	1	3
Final weight	....	154	150	130	434	....	100	138	168	406
Feed eaten and gains...	978.5	89	64	65	218	961.0	36	58	72	166

* S = Sow. B = Barrow.

Table showing results of feeding whole corn and corn meal to young growing pigs — Second trial — Lots I and II.

	LOT I — FED CORN.					LOT II — FED CORN MEAL.				
	Feed eaten.	1 S*	2 B	3 B	Total	Feed eaten.	4 S	5 S	6 B	Total
Weight at beginning, Oct. 19	Lbs.	Lbs. 159	Lbs. 126	Lbs. 113	Lbs. 398	Lbs.	Lbs. 150	Lbs. 136	Lbs. 117	Lbs. 403
Feed and gain:										
1st week	106.1	14	7	3	24	99.4	9	11	12	32
2d week	106.1	7	3	8	18	99.4	7	7	7	21
3d week	127.2	10	7	8	25	112	5	4	8	17
4th week	124	5	0	—1	4	118	6	4	0	10
5th week	89	0	9	3	12	103	7	5	10	22
6th week	102	13	4	7	24	103	6	5	6	17
7th week	96	4	4	8	16	96	7	10	6	23
8th week	112	9	5	3	17	112	6	—2	7	11
9th week	116	12	3	8	23	116	13	11	13	37
10th week	112	4	14	3	21	112	3	14	8	25
11th week	112	11	12	4	27	112	11	2	8	21
12th week	112	10	10	9	29	112	7	13	5	25
13th week	112	2	7	6	15	112	3	2	8	13
Final weight ..	....	260	211	182	653	....	240	222	215	677
Feed eaten and gain..	1426.4	101	85	69	255	1406.8	90	86	98	274

* S = Sow. B = Barrow.

In these tables it will be seen that pens II and IV, containing the Razorbacks, gave poorer returns for the feed supplied than did pens I and III, containing the pigs of mixed breeding. Further, we note that the pigs used in the second trial ate more feed for a given gain than did the pigs in pens I and III. This is because they had been much longer confined and kept on the feeds here named. Experience shows that pigs cannot be kept long in confinement and supplied with a limited variety of feeding stuffs, and thrive as they should.

Summarizing the data given in the previous tables, we deduce the following table, which shows weights, gains, etc.

Table showing weights, feed eaten, gain and feed per 100 pounds of gain, with pigs fed whole corn and corn meal.

	Av. weight at beginning.	Total feed eaten.	Total gain.	FEED FOR 100 LBS. GAIN.	
				Whole corn.	Corn meal.
First Trial.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.
Pen I, whole corn	70	1,038.4	234	444	....
Pen II, corn meal	72	978.5	218	....	449
Pen III, whole corn	80	1,004.2	169	594	....
Pen IV, corn meal	80	961.0	166	....	579
Second Trial.					
Pen I whole corn	133	1,426.4	255	559	....
Pen II corn meal	134	1,4 6.8	274	....	513

It will be seen that in one instance the pigs receiving whole corn made a hundred pounds of gain on less feed than those getting corn meal, while in the other two cases less ground corn was required for 100 pounds of gain than whole corn. Summarizing the results still further we find the following:

Comparing pens I and II there was a loss of one per cent. by grinding the corn to meal.

Comparing pens III and IV there was a saving of three per cent. by grinding the corn to meal.

In the second trial, comparing pens I and II, there was a saving of eight per cent. by grinding the corn to meal.

RESULTS OF SEVEN YEARS' TRIALS.

We now have conducted trials extending over seven years to determine the relative merits of whole corn and ground corn as a feed for swine. In previous years our animals were usually of the age at which they are commonly fattened by farmers and stockmen. This year the pigs were younger. In all cases some wheat middlings have been fed along with the corn as a part of the ration. Usually there was fed one part of middlings to two parts of corn or corn meal, by weight. This year the feed was half wheat middlings and half corn or corn meal, by weight. The results of the seven years' trials are summarized in the following table:

Table showing results of feeding whole corn versus corn meal to 220 hogs or pigs in all, divided into even lots.

Report.	No. of pigs in each lot.	Average weight at beginning.	Condition at beginning.	Per cent. saved or lost.	
1896	9	350	Thin	8.0	Saved by grinding.
1896........	10	224	Fat..........	17.6	Saved by grinding.
1897........	9	211	Rather fat...	11.0	Saved by grinding.
1897........	7	190	Rather fat...	9.0	Lost by grinding.
1898........	8	185	Rather fat...	5.4	Saved by grinding.
1898.... .	8	184	Rather fat...	8.4	Saved by grinding.
1899.......	19	186	Rather fat ..	2.0	Lost by grinding.
1900.......	14	175	Rather fat...	15.0	Saved by grinding.
1901.... ..	12	146	Rather fat..	6.0	Saved by grinding.
1902........	6	71	Fair....	1.0	Lost by grinding.
1902	6	80	Fair.. ...	3.0	Saved by grinding.
1902..... ..	6	133	Rather fat...	8.0	Saved by grinding.

From the above it will be seen that in nine cases there was a saving through grinding the corn to meal, while in three cases there was a loss. The highest saving was 17.6 per cent., and the lowest 3 per cent. The highest loss was 9 per cent., and the lowest 1 per cent. In the above no allowance has been made for cost of grinding, the figures given being based entirely upon the gain or loss incurred while feeding.

EXPERIMENTS IN PIG FEEDING.

I. Results of an Experiment to Determine the Comparative Effect upon the Growth, Development and Character of the Carcass of Pigs Fed upon Rations of Ground Peas and Corn Meal.

W. L. CARLYLE AND T. F. McCONNELL.

The 18th Annual Report of this Station, published last year, gave the result of an experiment in feeding young pigs from weaning time until slaughter upon rations of corn meal and ground peas. The experiment here reported began in August, 1901, shortly after the young pigs were weaned and was continued until February, 1902, a period of twenty-eight weeks. It is apparent to the writers that if conclusive evidence is ever obtained concerning the feeding value of any product as to its value in producing gains and its effect upon the carcass, etc., of the animal, the feeding period must begin very early in the animal's life and be continued for as long a period as possible consistent with the stage of maturity at which the animal should be marketed. For this reason this experiment was continued with pigs from weaning time until slaughter, and in future we hope to begin all such trials at the birth of the animal and continue to the slaughtering period.

CONDUCT OF EXPERIMENT.

The trial here reported began August 17th, 1901, with fourteen pigs. The breeding, sex, age in days and weight of each lot at the beginning of the experiment is given in the accompanying table. The Razorback pigs were the offspring of a pair of these pigs secured by the Experiment Station from the

wilds of Texas for experimental feeding and breeding. The cross-bred pigs were the result of breeding some of our best pure-bred Berkshire and Poland-China sows to the Razorback boar, and the quarter-bred Razorbacks were the result of crossing Poland-China and Berkshire boars upon cross-bred sows, giving the pigs one-quarter Razorback blood and three-quarters of Poland-China or Berkshire blood respectively.

TABLE No. I.— *Data concerning pigs at the beginning of the experiment, August 17, 1901.*

LOT I.— PEAS.					LOT II.— CORN.				
Record Number.	Breeding.	Sex.	Age	Wt.	Record number.	Breeding.	Sex.	Age.	Wt
			Days	Lbs.				Days	Lbs.
5	Razor-back ¼ Pol.-China ¾.	Barrow.	149	73	3	Razor-back ¼ Pol.-China ¾..	Barrow.	149	88
14	Poland-China .	Sow	147	90	11	Poland-China..	Barrow.	147	83
49	Berkshire......	Barrow	125	70	22	Berkshire	Barrow.	144	72
111	Razor-back ¼ Berkshire ¾ .	Barrow.	123	61	82	Razor-back ¼ Berkshire ¾ ..	Sow	123	57
86	Razor-back Poland China.	Barrow.	120	64	84	Razor-back Poland-China.	Barrow.	120	64
98	Razor-back Berkshire	Barrow.	100	52	80	Razor-back Berkshire	Barrow.	100	50
68	Razor-back	Barrow.	113	69	73	Razor-back.....	Barrow.	113	65
	Total weight..	....		479		Total weight..	....	......	479

FEEDING OF THE PIGS.

As will be seen from the above table, the pigs were evenly divided into two lots, one of which was fed ground peas and the other corn meal, the grain being made into a slop, with water immediately before each feeding time. Each pig was fed in a stall by itself and after finishing its feed, which consisted of as much as it would eat clean with a relish three times each day, it was turned into a large pen in company with the others of its lot. The pen was furnished with an earthen floor, adjoining which was a small inclosed yard for each lot to which they had access at will. Each pig was given a constant supply of

salt in one corner of its feeding pen, besides all the wood ashes each lot would consume in its yard. Each pig ate approximately one-tenth of a pound of salt each month, no appreciable difference being noticed between the lots in this respect. One of the pigs (No. 5) in Lot I, a quarter-bred Razorback Poland-China, died from congestion of the lungs about two months after the experiment began. As this pig had been fed separately its loss did not in any way affect the experiment in so far as the other pigs in the lot were concerned; consequently no data are given for this pig in this report.

DISCUSSION OF RESULTS.

Table No. II presents in two-week periods the amount of feed eaten, the weights and gains, etc., of each separate pig in the experiment. A glance at this table will serve to show that all of the pigs in Lot I fed on peas and No. 3 pig in Lot II fed on corn, made fairly constant gains and were liberal feeders during the entire experiment; consequently they were ready for slaughter four weeks in advance of the remaining six pigs in the corn-fed lot. It was noticed that during the first six or eight weeks of the experiment the corn-fed lot were a trifle more anxious for their feed and ate on the average just as much of it as did the lot getting peas, but from this time forward, that is to say, from the eighth week or fourth period to the end of the experiment, the lot fed corn did not appear to relish their feed and were quite uncertain in their appetites. This was especially true of pigs number 84, 80 and 73, the latter showing all the observed peculiarities of its breed in its aversion for continued liberal quantities of one kind of feed. It may be said here in passing that the original pair of Razorbacks never thrived well on a ration restricted to concentrated grain feed of any kind fed singly or all kinds combined. It is noteworthy that the pigs of Lot I made fairly constant gains during the entire experiment until the tenth period was passed, when their gains diminished perceptibly even while they maintained good appetites and ate a slightly increased amount of feed during the eleventh period. In the twelfth two-week period, however, their appetites appeared to

TABLE II.—*Showing amount of feed eaten, initial and final weights, gain of the individuals in two-week periods, etc.*

LOT I.—PEAS.

	5		14		49		111		86		98		68		LOT I.	
	Feed.	Gain.	Feed.	Gain.	Feed.	Gain.	Feed.	Gain.	Feed.	Gain.	Feed.	Gain.	Feed.	Gain.	Total feed.	Total wt and gain.
	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.
Weight at beginning	.... Died	.... Died.	....	90	....	70	....	61	....	64	....	52	....	69	....	479
1st period	....	....	29.1	7	29.1	9	29.1	22	29.1	12	29.1	14	29.1	8	174.6	72
2d period	....	....	33.6	8	33.6	9	33.6	5	33.6	5	33.6	9	33.6	8	201.6	44
3d period	....	....	39.6	12	39.6	11	39.6	11	39.6	13	39.6	14	36.6	11	231.6	72
4th period	....	....	53.0	11	53.0	16	53.0	12	53.0	14	53.0	11	53.0	13	318.0	77
5th period	....	....	59.0	14	59.0	19	59.0	17	59.0	15	59.0	17	59.0	16	354.0	98
6th period	....	....	64.1	16	64.1	14	64.1	13	64.1	17	64.1	13	52.0	5	372.5	78
7th period	....	....	64.2	10	64.2	14	64.2	13	64.2	9	64.2	12	55.8	15	376.8	73
8th period	....	....	75.5	10	75.5	13	75.5	11	75.5	11	75.5	20	63.0	15	440.5	80
9th period	....	....	77.0	15	77.0	16	77.0	12	77.0	15	77.0	16	63.0	9	418.0	83
10th period	....	....	75.5	13	75.5	15	75.5	9	75.5	10	75.5	14	59.5	9	437.0	70
11th period	....	....	77.0	7	77.0	7	77.0	3	77.0	17	77.0	12	60.0	7	445.0	53
12th period	....	....	68.5	7	65.0	7	3.5	11	63.5	6	63.5	7	51.0	6	375.0	44
Total feed and gain	....	....	716.1	130	712.6	150	711.1	139	711.1	144	711.1	159	615.6	122	4,177.6	844

LOT II.—CORN.

	3		11		22		82		84		80		73		LOT II.	
Weight at beginning	....	85	....	83	....	72	....	57	....	64	....	50	....	65	....	479
1st period	29.6	2	29.6	2	29.6	7	29.6	21	29.6	7	29.6	8	29.6	6	207.2	53
2d period	33.6	7	33.6	—1	33.6	5	33.6	6	33.6	4	33.6	7	33.6	7	235.2	35
3d period	41.0	9	32.5	6	41.0	11	41.0	11	33.5	7	32.0	4	32.0	8	253.0	56
4th period	53.3	11	42.3	9	53.3	10	53.3	13	39.3	10	38.3	6	38.3	8	318.1	67
5th period	59.4	15	54.1	11	59.4	13	55.1	11	41.5	12	35.0	9	37.0	6	341.5	77
6th period	63.2	14	57.6	4	60.2	10	56.0	10	41.6	6	38.6	7	39.6	7	356.8	58
7th period	64.6	12	59.1	11	58.5	7	58.8	7	44.6	9	43.6	6	42.6	3	369.8	55
8th period	74.5	15	60.9	11	60.9	12	60.9	12	46.9	7	46.9	10	46.9	4	397.9	71
9th period	74.5	14	61.6	15	60.6	7	60.6	9	48.8	11	44.8	9	43.6	7	394.5	72
10th period	68.0	10	55.0	4	55.0	7	52.3	8	33.7	1	33.7	6	33.7	1	331.4	37
11th period	70.0	13	56.0	9	54.5	4	56.0	9	36.7	6	36.7	1	36.7	7	316.6	47
12th period	61.0	3	54.5	7	38.0	3	54.3	2	35.1	8	36.0	8	36.0	5	315.1	36
13th period	....	....	54.4	5	40.8	6	54.4	11	40.7	13	40.7	4	40.7	5	271.7	42
14th period	....	....	62.0	11	42.5	5	51.5	5	37.0	—8	39.0	4	39.0	4	271.0	21
Total feed and gain	692.7	125	713.2	104	685.9	107	717.6	135	542.6	93	528.5	89	529.3	74	4,409.8	727

cloy easily and they all fell off perceptibly in the amount of feed eaten, and a still greater reduction was noticed in the rate of gain. These observations might also be made concerning Lot II, fed on corn, except that the decline in their appetites came in the ninth period. At no time after the fourth period did the corn-fed lot consume as much feed as did the lot getting peas, nor did they at any time during the experiment gain as rapidly as the pea-fed lot. Attention is called to the fact, however, that both lots appeared to fluctuate in rate of gain in unison. For instance, in the second period the pea-fed lot decreased in gain from 72 lbs. in the first period to 44 lbs. in the second, while the corn-fed lot decreased from 53 lbs. gain in the first period to 35 lbs. in the second; both lots aso decreased somewhat in rate of gain during the sixth and seventh period. The six pigs in Lot I fed on peas, ate 4,177.6 lbs. of feed in 24 weeks and gained a total of 844 lbs. in weight, requiring 495 lbs. of peas to produce 100 lbs. of gain, while the seven pigs in Lot II fed on corn ate 4,409.8 lbs. of feed in 28 weeks and gained 727 lbs. in live weight, requiring 606 lbs. of feed to produce 100 lbs. of gain. From these data it will be seen that in this experiment at least, pigs fed on peas have much better appetites and will feed well for a longer period and make much greater gains on peas alone as a feed than will pigs of the same breeding, age and condition when fed upon corn. The experiment conducted last year with the same kinds of grain gave results of like character, but in a modified degree.

TABLE No. III.—*Summary of feed eaten and gain made by pigs*

	Lot I, Peas.	Lot II. Corn.
	Lbs.	Lbs.
Average amount of feed eaten per pig, per day	4.14	3 28
Average gain of each pig per day	.837	.540
Average amount of feed for 100 lbs. gain	495.0	606 0
Amount of digestible protein in 100 lbs. of feed	16 8	7.0
Amount of digestible carbohydrates in 100 lbs. of feed	51.8	66.7
Amount of digestible fat in 100 lbs. of feed	.7	4 3
Amount of digestible protein for 100 lbs of gain	83 16	47.874
Amount of digestible carbohydrates for 100 lbs. of gain	256.41	404.202
Amount of digestible fat for 100 lbs of gain	3.465	26 058
Nutritive ratio	1:3.18	1:9.75

A summary of the results showing the amount of feed eaten per pig in each lot with other interesting data, is presented in Table No. III. From this table it will be seen that the pigs fed peas ate on the average during the experiment .86 of a pound of feed more per pig per day and gained almost .3 of a pound more each day than did the pigs fed corn. A wide difference is observed in the composition of the feeds given the two lots. The ration of Lot I fed peas, has a superabundance of protein or flesh-forming material and is comparatively low in fat and carbohydrates, or the heat and energy producing material. From the composition of the two kinds of food we would naturally expect a wide difference in the character of the meat produced and upon the carcass and vital organs generally.

THE SLAUGHTER TESTS.

The result of these comparisons is given in Tables Nos. IV and V, from which it will be seen that in amount of blood and in size, weight and development of the liver, stomach and intestines, the pea-fed lot of pigs were quite superior to the lot fed corn. In development of fat about the internal organs, however, there is not so marked a difference in the two lots as might have been expected when the character of the feed given each lot is considered.

TABLE NO IV.

LOT I.—Peas.

Record number.	Breeding.	Live weight.	Dressed weight.	Weight of blood.	Weight of spleen.	Weight of liver.	Weight of heart.	Capacity of stomach.	Intestinal fat.	Kidney fat.	Length of small intestines.	Length of large intestine.	Length of body.	Weight of kidneys.
		Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Inches.	Inches.	Inches.	Ounces.
5	Razor-back ¼ Poland-China ¾	Died.												
14	Poland-China......	220	174	7.2	.3	3.4	.6	3.3	3.4	6 8	602	210	38.0	12.
49	Berkshire	220	172	6.2	.25	3.1	.6	4.7	3.0	7.5	691	230	42.0	9.
111	Razor-back ¼ Berkshire ¾	200	153	5.9	.2	2.6	.6	3 8	3.0	7.8	581	204	39.5	10.
86	Razor-back Poland-China ...	203	156	7 8	.3	4.2	.6	5.1	3.6	11 0	676	228	38.0	10.
98	Razor-back Berkshire	211	163	7 8	.2	3.6	.6	3.9	2.5	11.5	577	205	40 0	12.
68	Razor-back	191	149	6 6	.25	2.7	.4	2.4	3.7	10.7	549	192	37.0	9.
	Averages	208.3	161.2	6.92	.25	3.26	.5	3.86	3.2	9.2	613	212	39.	10.3

LOT II.—Corn.

Record number.	Breeding.	Live weight.	Dressed weight.	Weight of blood.	Weight of spleen.	Weight of liver.	Weight of heart.	Capacity of stomach.	Intestinal fat.	Kidney fat.	Length of small intestines.	Length of large intestine.	Length of body.	Weight of kidneys.
3	Razor-back ¼ Poland-China ¾.	213	171	5.3	.25	2.2	.5	5.6	4.3	11.0	547	194	38.0	8.
11	Poland-China.......	188	143	4.9	.1	2.9	.4	8.1	4 4	10.5	585	186	38.5	6.
22	Berkshire	179	139	4.5	.15	2.5	.5	6.4	3.4	7.1	644	166	41.5	6.
82	Razor-back ¼ Berkshire ¾......	192	150	4.9	.2	2.8	.5	7.2	3.7	7.9	720	188	40.5	6.
84 80	Bazor-back Poland-China.....	158	120	3.9	.15	3.0	.4	3.7	2.9	8 3	602	175	36.0	4.
73	Razor-back Berkshire	139	103	3.5	.2	2.8	.5	7.0	3.5	6.0	549	201	37.5	4.
	Razor-back	139	105	4.8	.2	2.1	.4	5.2	2.9	7 5	516	177	37.0	6.
	Averages	172.5	133	4.5	.18	2.6	.46	6.2	3.58	8.3	594.7	183.8	38.4	5.71

TABLE No. V.—*Amount of blood, spleen, liver, heart, kidneys, etc., for each 100 lbs. dressed weight of hog.*

LOT I.—Peas.

Rec. No.	Breed.	Blood.	Spleen.	Liver.	Heart.	Kid-neys.	Kid-ney fat.	Intes-tinal fat.	Per cent. dress'd
		Lbs.	Lbs.	Lbs.	Lbs.	Oz.	Lbs.	Lbs.	
14	Poland-China....	4.132	.1724	1.954	.3448	6.896	3 908	1.954	79 09
49	Berkshire	3.604	.1453	1.802	.3494	5.232	4.302	1.744	78 18
111	Razor-back ¼ Poland-China ¾	3.856	.1207	1.699	.3921	6.535	5.098	1.960	76.50
86	Razor-back-Poland-China ..	5.000	.1923	2.692	.3846	6.410	7.051	2.307	75.00
98	Razor-back-Berkshire	4.785	.1926	2.208	.3680	7.361	7.035	1.533	77.25
68	Razor-back	4.429	.1677	1.812	.2684	6.040	7.181	2.483	78 01
	Average.	**4.229**	**.1551**	**2.027**	**.3512**	**6.429**	**5.765**	**1.996**	**77.33**

LOT II.—Corn.

Rec. No.	Breed.	Blood.	Spleen.	Liver.	Heart.	Kid-neys.	Kid-ney fat.	Intes-tinal fat.	Per cent. dress'd
3	Razor-back ¼ Poland-China ¾	3.039	.1461	1.287	.2923	4.678	6.432	2.514	80.02
11	Poland-China....	3 426	.0693	2.027	.2797	4.195	7.342	3.076	76.06
22	Berkshire	3.237	.1079	1.798	.3597	4.316	5.136	2.446	77.65
82	Razor-back ¼ Berkshire ¾	3.266	.1333	1.866	.3333	4 000	5.246	2.466	78.12
84	Razor-back-Poland-China...	3.250	.1250	2.500	.3333	3.333	6.925	2.416	75.88
80	Razor-back-Berkshire	3.398	.1941	2.718	.4854	3.383	5.825	3.398	74.10
73	Razor-back	4.571	.2000	2.000	.3809	5.714	7.142	2.761	75 53
	Average.......	**3.463**	**.1351**	**2.028**	**.3520**	**4.374**	**6.292**	**2.725**	**76.76**

The accompanying photographs taken of a cross-section of each one of the pigs on the experiment shows the development of muscle and of fat in each pair of pigs, litter brothers, one of which was fed on corn and the other on peas. Note particularly the large development of the muscles on each side of the back bone of the carcasses fed peas as compared with those fed corn. While the layer of fat on the outside of carcass is not greatly different in pigs fed peas from those fed corn, partly owing to the better appetites and greater growth and development of the pea-fed lot, yet the amount of lean meat or muscle is so small in the corn-fed lot that the difference in proportion of lean to fat in the different carcasses is readily discernible. After the first group of pigs had been slaughtered, three of the butchers employed in doing the work were in turn asked to select the carcass showing the most soft and flabby quality of meat. Without exception the three men selected the corn-fed pig No. 3 that was killed at the same time the pea-fed lot were.

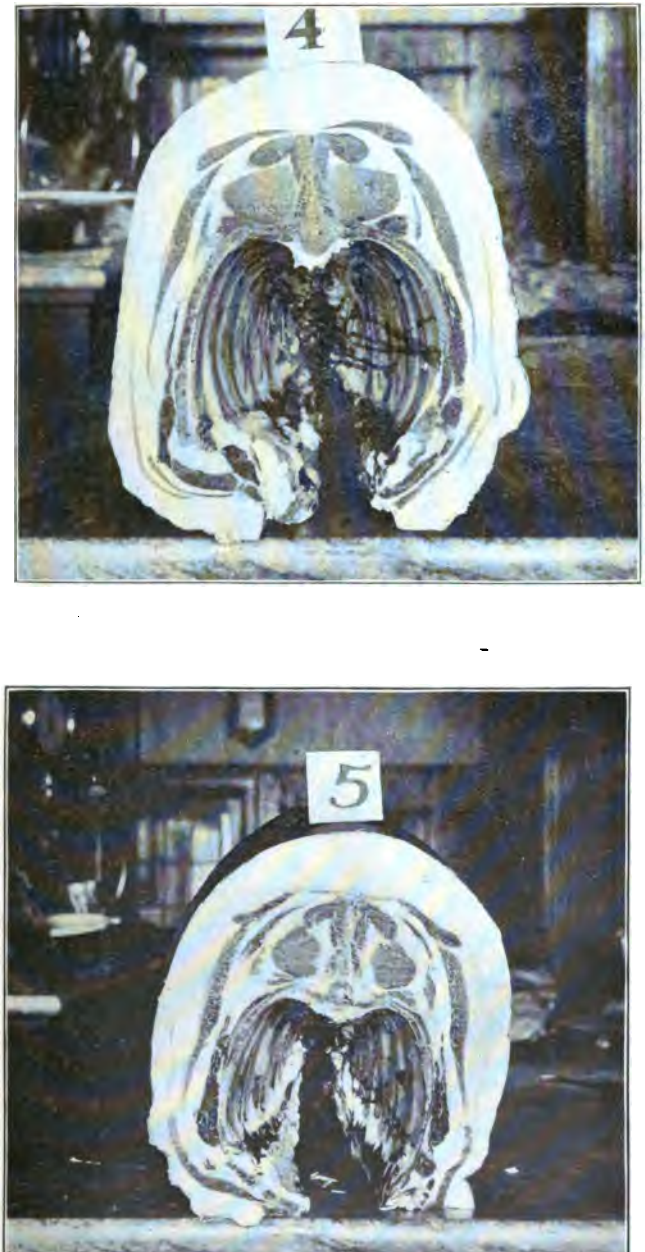

FIG. 1.—Showing cross sections of a pair of Poland China pigs from same litter. The one above of pig No. 14 fed on ground peas, the one below of pig No. 11 on ground corn.

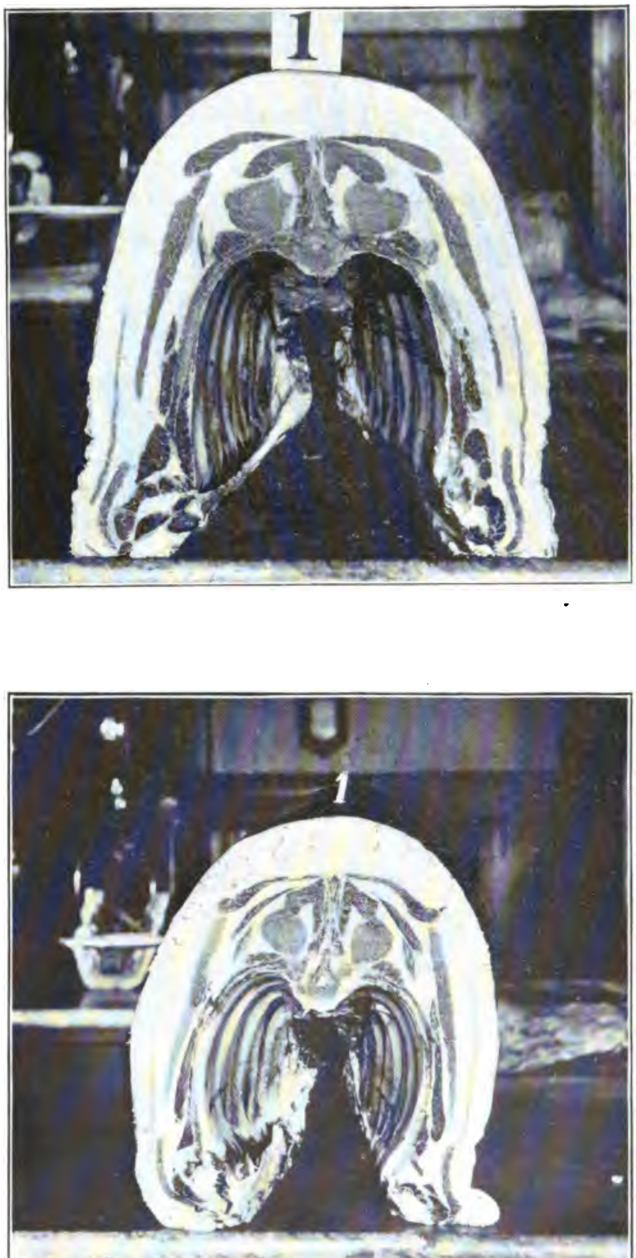

FIG. 2.—Showing cross sections of a pair of Berkshire pigs from same litter. The one above of pig No. 49 fed on ground peas, the one below of pig No. 22 fed on ground corn.

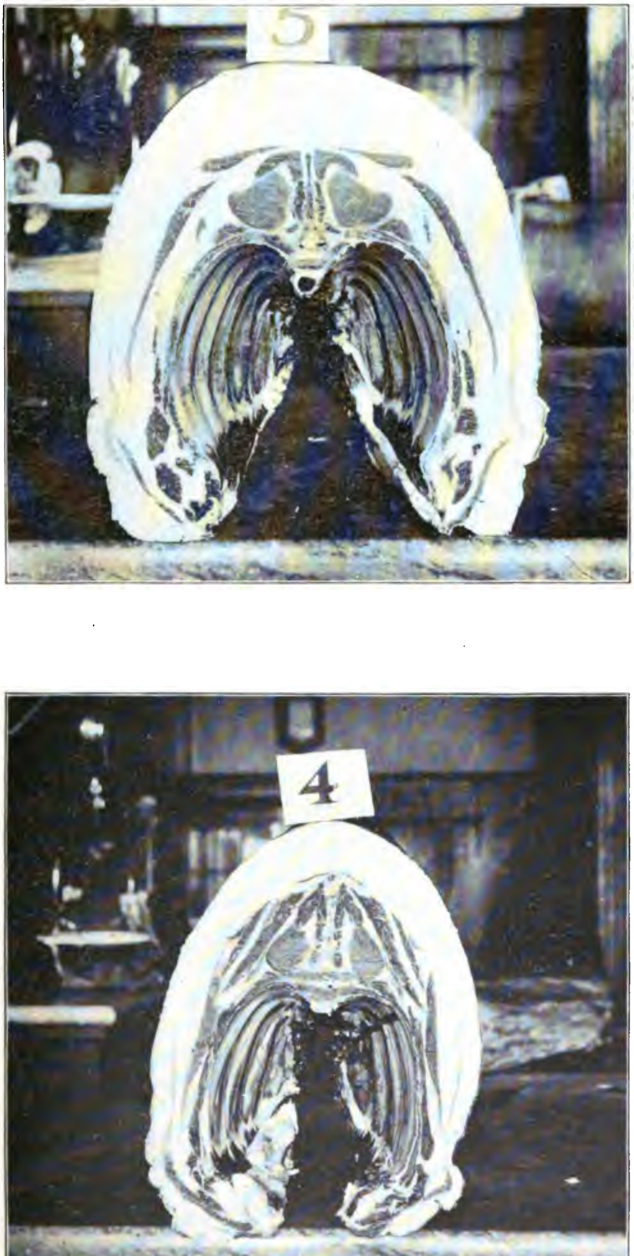

FIG. 3.—Showing cross sections of a pair of Razorback pigs from the same litter. The one above of pig No. 68 fed on ground peas, the one below of pig No. 73 fed ground corn.

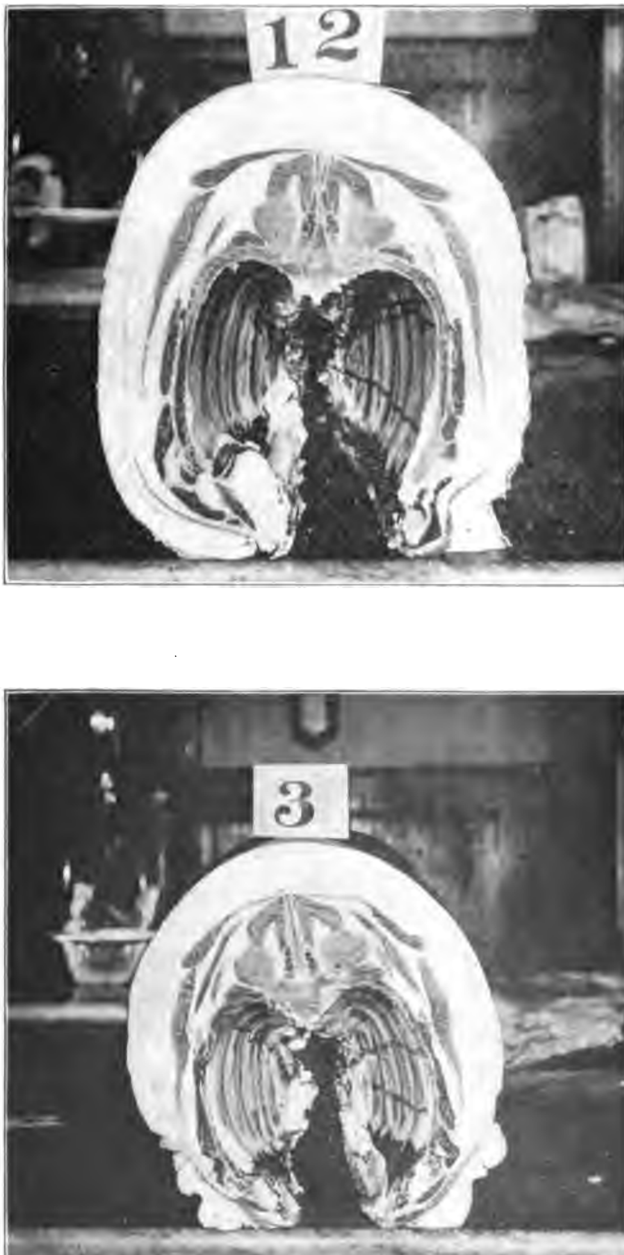

FIG. 4.—Showing cross sections of a pair of cross bred Razorback-Poland Chinas. The one above of pig No. 86 fed on ground peas, the one below of pig No. 84 fed ground corn.

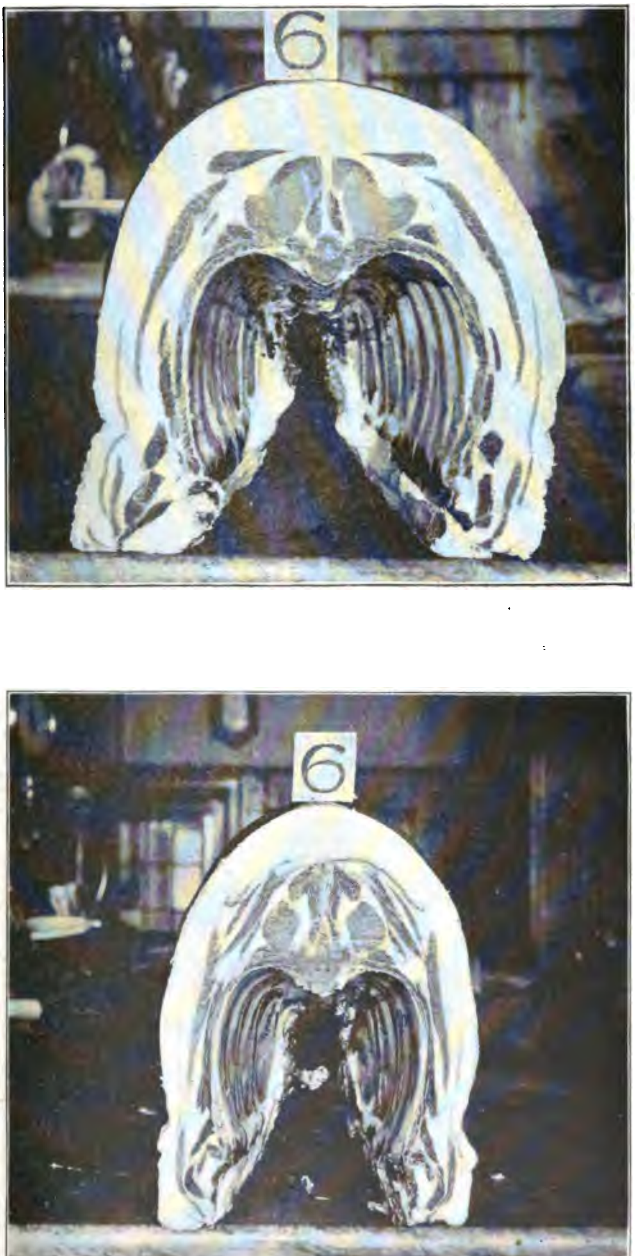

FIG. 5.—Showing cross sections of a pair of cross-bred Razorback-Berkshires. The one above of pig No. 98 fed on ground peas, the one below of pig No. 80 fed ground corn.

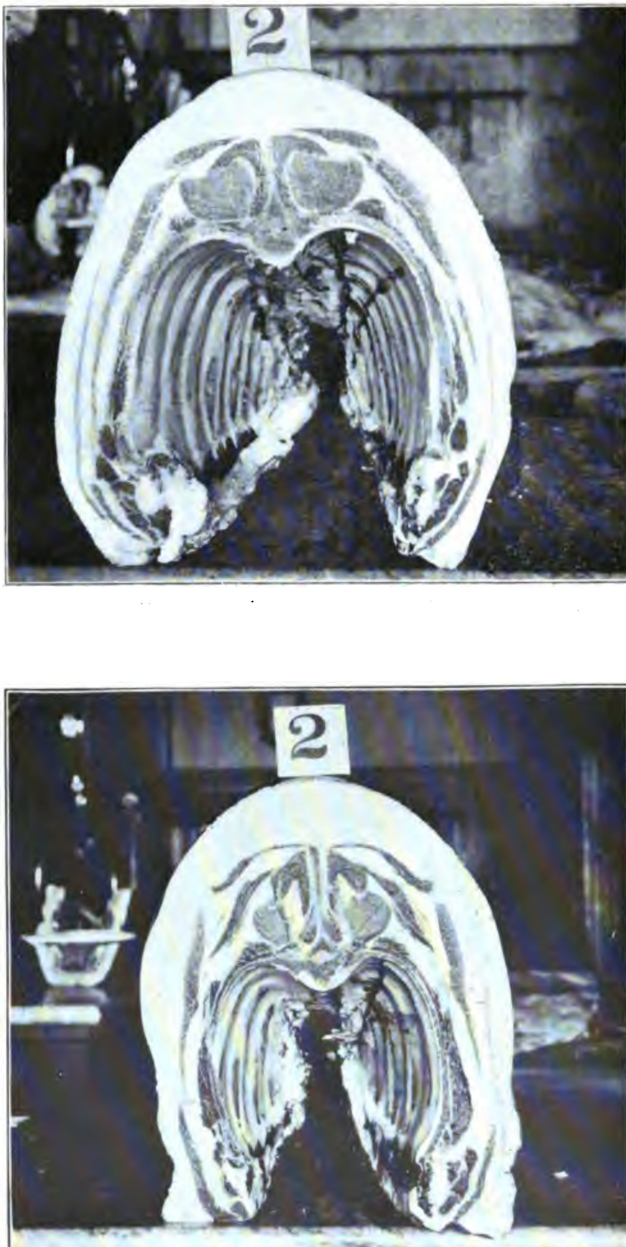

FIG. 6.—Shwing cross sections of a pair of one-quarter bred Razorback and three-quarters Berkshire pigs. The one above of pig No. 111 fed on ground peas, the one below of pig No. 82 fed ground corn.

The quality of meat in this carcass fairly represented that of all the corn-fed lot; the fat was soft and flabby, almost blubbery to the touch, and the muscle was pale in color and appeared to lack tone.

COMPARISON OF RESULTS BY BREEDS.

While the primary object of this experiment was a determination of the comparative value and the comparative effect upon the carcass of feeding corn and peas to hogs, a secondary object has been accomplished in a comparison of the feeding powers and the returns for food consumed by the different breeds and crosses represented by the pigs in the experiment. By referring to Table No. VI the results of such comparison are given in

TABLE No. VI.—*Comparing amount of feed eaten, rate of gain of each pig with the average of each breed represented.*

Record No.	Breed.	Kind of feed.	Average amount of grain eaten per day.	Average daily gain of each pig.	Total gain of each pig.	Amount of feed for 100 lbs. gain.	Amount of internal fat.	Dressed weight.
			Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.
14	Poland-China..	Peas..	4.28	.77	130	550	10.2	174
11	Poland-China..	Corn.	3.63	.53	104	685	14 9	143
	Average.....	....	**3.95**	**.65**	**117**	**617**	**12.55**	**158.5**
49	Berkshire......	Peas..	4.24	89	150	475	10 5	172
22	Berkshire......	Corn..	3.5	.54	107	641	10.52	139
	Average.....	....	**3.87**	**.71**	**128**	**558**	**10.51**	**155.5**
86	Razor-back-Poland-China	Peas..	4.23	.85	144	493	14 6	156
84	Razor-back-Poland-China	Corn..	2 77	.48	93	582	11.21	120
	Average,.....	....	**3.50**	**.66**	**118**	**538**	**12.90**	**138**
98	Razor-back-Berkshire....	Peas..	4.23	.94	159	447	14.	163
80	Razor-back-Berkshire....	Corn..	2 69	.45	89	594	9.5	103
	Average.....	....	**3.46**	**.69**	**124**	**520**	**11.75**	**133**
111	¼ Razor-back ¾ Berkshire..	Peas..	4.23	.82	139	511	10.8	153
82	¼ Razor-back ¾ Berkshire..	Corn..	3.66	.68	135	531	11.57	150
	Average.....	....	**3.94**	**.75**	**137**	**520**	**11.18**	**151.5**
3	¼ Razor-back ¾ Pol'd-China	Corn..	4 12	.61	125	685	15.3	171
68	Razor-back....	Peas..	3.66	.72	122	504	14.4	149
73	Razor-back....	Corn..	2.70	.38	74	715	10.4	105
	Average.....	....	**3.18**	**.55**	**98**	**609**	**12.4**	**127**

tabulated form. It should be borne in mind that there were two pigs representing each breed and cross. During the experiment one pig of each of these pairs was fed on peas and the other on corn so that by averaging the results of the feeding, rate of grain, etc., of each pair we get some indication of the comparative feeding qualities of the pigs of the different breeds and crosses. In the case of the quarter-bred Razorback Poland-China pigs the data for only one pig, that fed the corn ration, are given, the other having died as mentioned before.

Pig No. 3, a quarter-bred Razorback-Poland-China, it will be seen, ate the largest average amount of feed per day, the pure-bred Poland-China pair coming second in this respect and the pure-bred Razorback pair last, eating almost a pound of feed less per day on the average than the quarter-bred Razorback-Poland-China. The surprising part of the table, however, is found in the third and fifth columns where the average daily gain per pig of each breed and cross, and the amount of feed required for 100 lbs. of gain, is shown. In these columns we notice that the Poland-Chinas made the smallest average daily gain per pig of any breed or cross except the pure-bred Razorbacks and required the greatest amount of feed to produce 100 lbs. of gain, not excepting the last mentioned breed. The quarter-bred Razorback Berkshires made the greatest average daily gain per pig and consumed the least amount of feed for 100 lbs. gain, the half-bred Razorback-Berkshires coming second, the half-bred Razorback-Poland-Chinas third and the Berkshires in the fourth place. The Poland-China and the Razorback pigs requiring 59 lbs. and 51 lbs. respectively, more feed to produce 100 lbs. of gain than any of the other pairs. It is noteworthy also that the smallest quantity of feed required by any one pig for 100 lbs. of gain was 447 lbs. of peas when consumed by a half-bred Razorback Berkshire, this pig being one of the heaviest feeders. The next smallest quantity of feed for 100 lbs. of gain was 475 lbs. of peas when consumed by a pure-bred Berkshire, this pig being the second heaviest feeder on the experiment. The heaviest feeder on the experiment was a pure-bred Poland-China, which required 550 lbs. of peas for 100 lbs. of gain,

over 100 lbs. more of the same kind of feed being required for 100 lbs. of gain in this pig than was required by the Razorback Berkshires, and yet both pigs made fairly good gains during the entire experiment. This fact seems to clearly demonstrate what a surprising effect the individuality of an animal may have upon the results of an experiment and serves to illustrate the importance of large numbers and long continued experiments with animals along any one line of feeding, to obviate inevitable errors, the result of wide differences in the peculiarities of individuals, before definite conclusions are drawn.

The last column but one of the table shows a wide variation in the amount and proportion of loose or internal fat of the various pigs. It is apparent that neither the rate of gain, the breed of pig nor the dressed weight was responsible for this variation. We must conclude, therefore, that this peculiarity is also due in large measure to the idiosyncrasies of the individual animal.

II. The Results of a Feeding Trial Comparing Razorback with Cross-Bred Razorback and Improved Breeds of Hogs.

W. L. CARLYLE.

There is a very general impression among certain classes of stockmen to the effect that unimproved or scrub stock will make as good gains in weight for feed consumed as animals of good breeding. The experiment here reported was undertaken with the object of determining if pure bred Razorback pigs would consume as much feed of the same kind and make as much live weight gain therefrom as pigs having one-half Razorback and one-half Poland-China or Berkshire blood.

PLAN OF EXPERIMENT.

A number of pigs of the above mentioned breeding had been on a feeding trial for twelve weeks comparing ground and unground corn. Twelve pigs were chosen from this lot that

would represent as fairly as possible the type of pigs in each class selected, six of these were Razorback pigs, three from each of two litters. The other six pigs were sired by a Razorback boar, three of them out of a Berkshire sow, and three out of a Poland-China sow.

The Razorback pigs were confined in a roomy pen with a small yard adjoining, the six cross-bred pigs having a similar pen and yard. Twice each day, during the experiment, both lots were fed all they would eat of ground corn, ground rye and shorts mixed in equal parts by weights. At the end of the fourth week it was decided to add skim milk to the ration of each lot. The intention was to feed two parts of skim milk to one part of the grain feed but owing to an unavoidable variation in the supply of milk the proportion on the average was approximately 1 part of grain to 1.4 milk in both lots.

TABLE I.—*Initial weights, weekly gains and feed with total weights, gains and feed eaten by Razor-back pigs.*

	1ST GENERATION.			Total gain and Weight	2ND GENERATION.			Total gain and weight.	Total gain and weight of both generations.	Total feed of both generations.	Skim milk.
Numbers of pigs ..	71	72	74		61	62	64				
	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.
Initial weights	99	118	141	358	149	175	162	486	844	......	......
Gain, 1st week ...	4	−3	−4	−3	3	3	5	11	8	140.1	......
Gain, 2d week....	4	3	−1	6	8	7	7	22	28	133.1	......
Gain, 3d week....	3	4	2	9	4	−1	3	6	15	128	......
Gain, 4th week....	7	4	8	19	5	......	3	8	27	138	......
Gain, 5th week....	11	13	8	32	28	22	8	58	90	163	240
Gain, 6th week....	7	5	6	18	3	9	12	24	42	177	352
Gain, 7th week....	10	10	16	36	......	−3	20	17	53	210	395
Gain, 8th week....	8	10	2	20	18	29	1	48	68	210	420
Gain, 9th week....	1	1	6	8	2	4	13	19	27	210	420
Gain, 10th week....	11	11	16	38	9	5	14	28	66	217.5	440
Gain, 11th week....	8	5	......	13	12	12	1	25	38	210	390
Total gain......	74	63	59	196	92	87	87	266	462	1934.5	2657
Final weight ..	173	181	200	554	241	262	249	752	1306	......	......

DISCUSSION OF RESULTS.

The accompanying tables giving the data concerning the initial weights of each lot of pigs, the amount of feed eaten and the gains made, show some interesting results. The cross-bred pigs ate appreciably larger quantities of grain than did

the Razorback lot and made even greater gains in proportion to feed consumed.

During the first four weeks while on grain feed alone neither of the lots made very large gains though the cross-bred pigs gained more than the Razorbacks. After the milk feeding began, however, the weekly gains made in the case of some of the pigs was very remarkable, the cross-bred pigs gaining on the average over two pounds each every day for over two weeks, some of the individual pigs making a gain of over three pounds daily. There were occasional instances of even greater gains than this for individual pigs in the Razorback lot but only for one week; the week preceding and the one succeeding showing little or no gains in every case. This peculiarity may be accounted for in part at least by the varying amounts of feed consumed immediately before weighing though the feeding and weighing were done with great regularity in every instance. It was noticed, however, that the Razorback pigs especially were exceedingly variable in their appetites, frequently gorging themselves and then eating sparingly for several feeds followed by another gorge.

TABLE II.—*Initial weights, weekly gain and feed, with total weights, gain and feed eaten by cross-bred Razor-back Poland-China and Razor-back Berkshire pigs.*

	RAZOR-BACK POLAND-CHINAS.			Total gain and weight.	RAZOR-BACK BERKSHIRES.			Total gain and weight.	Total weight and gain of both crosses.	Total feed of both crosses.	Skim milk.
Numbers of pigs...	83	85	89		97	101	112				
	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.
Initial weights	156	156	162	474	153	151	135	439	913	......	......
Gain, 1st week ...	4	3	7	14	1	0	3	4	18	140	......
Gain, 2d week ...	5	5	6	16	10	4	8	22	38	154	......
Gain, 3d week ...	13	5	10	28	7	10	7	24	52	193.5	......
Gain, 4th week ...	7	13	8	28	13	7	11	31	59	213	.....
Gain, 5th week ...	15	16	17	48	14	20	15	49	97	247.5	348
Gain, 6th week ...	11	22	14	47	21	14	16	51	98	259.5	524
Gain, 7th week ...	10	12	9	31	15	3	9	27	58	273	560
Gain, 8th week ...	2	17	13	32	11	19	13	43	75	273	560
Gain, 9th week ..	10	−2	11	19	8	3	11	22	41	273	560
Gain, 10th week ...	15	25	13	53	19	11	12	42	95	292.5	612
Gain, 11th week ...	4	12	14	30	12	16	15	43	73	269	572
Total gain	96	128	122	346	131	107	120	358	704	2588.0	3736
Final weight ..	252	284	284	820	284	258	255	797	1,617	......	......

This could not be prevented entirely since all the pigs in each lot were fed together, and while the lot were fed no more

at any one time than they would eat, yet some were always eating too much while others would not eat enough. An explanation of this tendency in these pigs might possibly be found to be inherited peculiarities of their wild ancestors resulting from their irregular food supplies. The cross-bred pigs made a total gain of 704 lbs. in the eleven weeks of the experiment, the Razorbacks meanwhile making a gain of 407 lbs.; the latter consuming 1,934.5 lbs. of the mixed grain feed and 2,657 lbs. of skim milk while the former ate 2,578 lbs. of the grain and 3,736 lbs. of skim milk.

The Razorback pigs ate on the average 4.18 lbs. each of grain feed daily and an average of 9 lbs. of skim milk each daily for the last seven weeks of the experiment while the cross-bred pigs ate 5.56 lbs. of grain and 12.7 lbs. of the milk during this period. Comparing the average amount of grain eaten for 100 lbs. of live weight gain made as seen in table number III there is a marked difference in favor of the cross bred pigs; the Razorbacks requiring on the average 54 lbs. more of grain to produce 100 lbs. of gain. If for the sake of comparison we consider the mixture of grain worth $1.00 per hundred it would cost a trifle over one-half cent more to produce a pound of live weight gain with Razorback pigs than where cross-bred Razorback Poland-Chinas and Berkshires were fed.

THE VALUE OF SKIM MILK.

Both lots of pigs having been feed for four weeks on a mixture of grain fed without milk followed by seven weeks during which a limited quantity of skim-milk was fed in conjunction with the grain an excellent opportunty was afforded to measure the value of skim-milk as a factor in pig feeding when fed with a liberal grain ration. A glance at the tables presented will serve to show that as soon as the skim-milk was added to the ration the rate of gain was greatly increased. It will also be noticed that with skim-milk added to the ration, both lots of pigs ate much larger quantities of their grain feed which would seem to indicate that the addition of skim milk to an all grain ration not only results in a marked increase in

the rate of gain but at the same time affects a surprising influence on the appetites of the animals inducing them to eat much more freely of their grain ration than they were doing before the addition of the skim milk to their daily rations.

TABLE III.

	Cross bred.	Razor-back.
	Lbs.	Lbs.
Average amount of grain feed eaten daily	5.56	4.18
Average amount of milk eaten daily	12.7	9.0
Average amount of grain for 100 lbs. of gain	366.0	420.0
Average amount of milk for 100 lbs. of gain	530.0	565.0
Average daily gain of each pig	1.52	1.02
Average amount of grain for 100 lbs. gain the first four weeks	566.0	624.0
Average amount of grain for 100 lbs. gain the last seven weeks	331.0	364.0
Amount of grain feed saved by each 100 lbs. of milk fed	6.26	9.78

In the table giving the summary of this experiment it will be seen that during the first four weeks of the experiment when the pigs had no milk it required 566 lbs. of ground corn, ground rye and shorts, equal parts, to produce 100 lbs. of live weight gain on the cross-bred pigs and 624 lbs. of a similar mixture of grain feed to produce the same amount of gain on pure-bred Razorbacks. Comparing the amount of the same grain ration required to produce 100 lbs. of gain on the same pigs for the last seven weeks of the experiment when approximately one and four-tenths pounds of skim milk was fed with each one pound of the grain ration, we find that it required only 331 lbs. of grain to produce 100 lbs. gain on the cross-bred pigs and 364 lbs. for the Razorbacks. It will, therefore, be readily seen that the feeding of the skim milk resulted in a marked saving in the grain feed required for 100 lbs. of gain. Each 100 lbs. of the skim milk fed was found to be equivalent to 6.26 lbs. of grain for the cross-bred pigs and to 9.78 lbs. of grain for the Razorbacks. We cannot account for the marked difference in the effect upon the two lots of pigs of feeding the skim milk with the grain, except that we have invariably noticed that Razorback pigs never thrive well on a ration composed entirely of concentrated grain feed. They are always much more healthful and thrive better when they have access to abundant pasturage or bulky food of some sort than where restricted to an all grain diet.

FIG. 7.—Photograph of the old Razorback boar "Adam," the sire of all the Razorback pigs at the experiment station.

FIG. 8.—Photograph of the old Razorback sow "Eve," the dam of the Razorback pigs.

FIG. 9.—Photographs of the first generation of Razorback pigs under improved conditions.

FIG. 10.—Photographs of the second generation of Razorback pigs under improved conditions.

In table I it will be noticed that three of the six Razorback pigs are grouped together, one group consisting of the first generation of these pigs and the other of the second generation. One of the objects of breeding these Razorback hogs at the University Station is to determine the extent to which the environment of liberal feeding and suitable shelter will improve them in successive generations. The first generation mentioned above are the offspring of the original pair of Razorback hogs "Adam" and "Eve" shown on preceding page. The second generation are by the same boar as the first generation but out of a sow that was raised on the University farm though of pure unimproved Razorback ancestry. A comparison of the rate of gains made by the pigs of these two generations discloses some interesting points. It is to be regretted that each one of these pigs could not have been fed separately but owing to lack of accommodations this was not possible for the experiment under discussion. In the columns of table I giving the total gain and weight of each generation it will be seen that while the three pigs of the second generation made a gain of 266 lbs. in eleven weeks the three pigs of the first generation made a gain of only 196 lbs. It may be that the pigs of the first generation made as good gains for food consumed as those of the second generation yet the data presented clearly bear out the fact that they fell far behind in rate of gain and we may safely assume from their appearance as presented in accompanying photos that they were not nearly equal to the pigs of the second generation either in ability to consume large quantities of food or to assimilate and store the food nutrients in their body tissues.

A series of experiments along the same line as the above mentioned but much more extensive is being carried on the present year at the Experiment Station and we hope to present some further data along these lines in future reports.

As this is only a preliminary report of some of the work accomplished in the work of grading up these very inferior scrub hogs, we crave the reader's patience for the present until some conclusive deductions may be drawn concerning not only the wonderful influences of liberal supplies of feed and suitable

shelter in the improvement of this class of live stock but also the value of introducing some of the fresh, invigorating blood of these wild hogs into the sluggish delicate streams flowing through the veins of our over refined breeds of swine in the middle western states.

SOME OBSERVATIONS ON SHEEP BREEDING FROM THE EXPERIMENT STATION FLOCK RECORDS.

W. L. CARLYLE AND T. F. McCONNELL.

The breeder of live stock is frequently much confused by the lack of harmony in the statements made by authorities concerning the various phases of animal breeding. It is very apparent that there is a great lack of positive data available to serve as a guide in the direct paths to success in this most intricate of all callings. Much of the lack of definiteness in the available information relating to stock-breeding is largely due to the fact that so very few master breeders are careful to preserve a record of the various incidents that are of daily occurrence in the practical stockman's life.

Some twelve or fourteen years ago the Animal Husbandry department of this Station began keeping a record of the breeding operations in the sheep department. For the first years this included only the ear tag number of the service ram and ewes, the date of service, and the date of birth of the lambs. The record was gradually perfected until during the past four years it included the number of lambs dropped and their sex, the weight and condition of lambs at birth, the apparent milking qualities of the ewes, and the weights of the ewes and the service rams used. We are indebted to Professor Craig for the beginning and early conduct of this work and to the very efficient, systematic and painstaking manner in which the Station shepherd, Frank Kleinheinz, carried on the tabulation of this work since its inception.

THE PERIOD OF GESTATION AND INFLUENCES AFFECTING IT.

The Period of Gestation or Pregnancy of ewes is given by various authorities at from 147 to 152 days in length. Tessier, a French authority, gives the results of observations on 912 ewes extending over a period of 40 years in which the period of gestation varied from 146 days as the shortest period that a ewe carried her lamb to 161 days as the longest. He further observed that more than three-fourths of the ewes dropped their lambs between the 150th and 154th days after service. According to this authority the average would be about 152 days. The breeding calendars sent out by the various editors of private flock registers and ear label circulars give the period at either 147 or 150 days after date of service.

At the Experiment Station our service rams are kept separate from the flock during the breeding season and only turned with the ewes for a short time each day, during which, the shepherd or an assistant is on hand to note which ewes are in heat and which ones bred, consequently we have no difficulty in keeping an accurate record of the time of service of each ewe. From the accompanying table it will be seen that of 524 ewes that have been bred and dropped their lambs, the period of gestation has ranged from 140 to 156 days, and that the greatest number, 113 ewes or 21.6 per cent., dropped their lambs on the 146th day after service; the next greatest number, 81 ewes or 15.5 per cent., dropped their lambs 147 days after being bred and that 404 ewes or 77.1 per cent. dropped their lambs between the 144th and 150th days after service. Only two ewes carried their young for more than 154 days, one yeaning 155 and other 156 days after taking the ram while only one ewe yeaned as early as 140 days after service. All three of these ewes gave birth to dead lambs which would at least suggest that these extreme periods were abnormal. From the data here given representing as it does the various breeds of sheep we feel quite justified in stating that the extreme range of the normal period of gestation in breeding ewes is thirteen days beginning at 142 and extending to 154 days after service.

TABLE NO. I.

Number of days in period of gestation of ewes; also gestation period of ewes of different breeds and crosses.

Period of Gestation.	Total No. of Ewes.	Total per cent.	Shropshires and Grades	Dorse's and Cros'es	Southdowns.	Merinos.	Cross bred Shrop-Merinos.	Oxfords.
140 days	1	.2	1	....	....	....	....	....
141 days	....	....	....	....	....	....	....	....
142 days	7	1.3	4	1	....	....	2	....
143 days	9	1.7	5	3	....	....	1	....
144 days	34	6.5	14	14	3	....	3	....
145 days	73	13.9	39	12	9	....	13	1
146 days	113	21.6	54	17	8	1	23	3
147 days	81	15.5	41	17	5	1	17	....
148 days	76	14.5	46	21	3	1	11	....
149 days	61	11.7	25	18	4	3	11	....
150 days	31	5.9	22	5	....	....	3	....
151 days	18	3.4	14	4	....	....	....	....
152 days	8	1.5	5	1	....	2	....	....
153 days	6	1.1	2	4	....	....	....	....
154 days	4	.8	4	1	....	....	....	....
155 days	1	.2	....	....	....	....	1	....
156 days	1	.2	1	....	....	....	....	....
17 days	524	....	277	118	32	8	85	4

From these we may also safely conclude that the greatest number of ewes may be expected to drop their lambs at least six days earlier than was found by Tessier to be the case with breeding ewes in France. A glance at Table No. I shows us that this difference may be accounted for, in part, at least, by the peculiar characteristics of the various breeds. Of the 32 pure-bred Southdown ewes shown in this table it will be seen that 20 or 62.8 per cent. carried their lambs less than 147 days and that of the 8 pure-bred Merinos 6, or 75 per cent., carried their lambs over this period, while the Shropshire grades and the various crosses of Shropshires with Dorsets and Merinos occupy a middle position between the two above

mentioned breeds. From this it would seem that the more compact and quick maturing the breed the shorter the period of gestation and vice versa. Since the Merinos are much longer in reaching their maturity in breeding as well as in growth and general development than either the Southdown or the Shropshire we might reasonably expect them to carry their young a longer time. This conclusion would serve to explain the longer period of gestation noted in France since practically all of the sheep of that country are of the Merino type.

EFFECT OF MALE OR FEMALE OFFSPRING ON PERIOD OF GESTATION.

Many more or less intelligent stockmen are frequently heard to state that a male, is carried longer *in utero* than a female. From the data given in Table No. II on this point covering as it does a period of twelve years and representing many breeds of sheep, we cannot find any foundation for this belief as there is practically no difference in this respect. A glance at this table will also serve to show that for a period of years the proportion of males and females is practically the same, 49.94 per cent. males and 50.06 per cent. females having been dropped in the flock.

TABLE No. II.

Table showing effect of male and female offspring on period of gestation; also the proportion of males and females for a period of twelve years.

	142	143	144	145	146	147	148	149	150	151	152	153	154	Totals.
Males	6	17	29	66	83	62	66	43	18	10	7	3	....	410
Females	6	13	31	55	90	69	66	46	17	8	4	4	2	411
Per cent. males	50	56.7	48.3	54.5	48.0	47.3	50.0	48.3	51.4	55.6	63.6	42.9	....	49.94
Per cent. females	50	43.3	51.7	45.5	52.0	52.7	50.0	51.7	48.6	44.4	36.4	57.1	100	50.06

RELATION BETWEEN PERIOD OF GESTATION AND SIZE OF LAMBS.

For the better showing of the relation existing between the size of the lambs dropped and the period of gestation the lambs that had been weighed at birth were somewhat arbitrarily divided into three groups of small, medium, and large lambs. The small group consisted of all lambs weighing less than 8 lbs.; the medium group of all lambs weighing from 8 to 10 lbs. inclusive; and the large group of all lambs weighing above 10 lbs. at birth.

As seen in Table No. III of a total of 150 small lambs dropped during the extreme range of the period of gestation 90, or 60 per cent. were carried 146 days or less while 60, or but 40 per cent. of the small lambs were carried over 146 days. Of the medium group of 163 lambs, 70, or 43 per cent., were carried 146 days or less while 93, or 57 per cent., were dropped after 146 days of gestation.

TABLE No. III.

Percentage of small, medium and large lambs for each period of gestation.

Size of lambs.	142	143	144	145	146	147	148	149	150	151	152	153	Total.
Small, —8	5	7	16	29	33	22	15	12	4	4	1	2	150
Medium, 8 to 10..............	1	5	11	24	29	24	26	24	9	7	....	3	163
Large, 10+	1	2	4	5	19	16	18	16	6	5	4	2	98
Per cent. small	71.4	50.0	51.6	50.0	40.7	35.4	25.4	23.2	21.0	25.0	20.0	28.5	....
Per cent. medium	14.3	35.7	35.5	41.3	35.8	38.8	44.0	46.1	47.4	43.7	....	43.0	....
Per cent. large	14.3	14.3	12.9	8.7	23.5	25.8	30.6	30.7	31.6	31.3	80.0	28.5	....

In the group of 98 large lambs only 31, or 31.6 per cent., were carried 146 days or less and 67 lambs, or 68.4 per cent., were dropped between 146 and 153 days. From this we conclude that the small lambs or lambs averaging less than 8 pounds at birth are carried during the shortest period of gestation on the average and that the largest lambs or those over 10 pounds at birth are carried longer than either the medium or small lambs.

TABLE NO. IV.

Number and condition of lambs for each gestation period.

Gestation Period.	140	141	142	143	144	145	146	147	148
No. of lambs	2	......	10	29	60	122	169	141	138
Number dead	2	......	1	8	3	8	8	12	10
Per cent dead	100	......	10	27.6	5.0	6.5	4.7	8.5	7.2
Per cent. weak	......	......	......	10.3	6.6	4.0	4.1	1.4	7.9
Per cent. weak and dead	100	......	10.0	37.9	11.6	10.5	8.8	9.9	15.1
Per cent. strong	......	......	90.0	62.1	88.4	89.4	91.2	90.1	84.9

TABLE NO. IV—continued.

	149	150	151	152	153	154	155	156
No. of lambs	95	45	24	11	8	5	1	2
Number dead	5	17	13	6	......	2	......	2
Per cent. dead	5.2	37.7	54.1	55.5	......	40.0	......	100.0
Per cent. weak	3.1	6.6	......	......	25.0	......	100.0	......
Per cent. weak and dead	8.3	44.3	54.1	55.5	25.0	40.0	100.0	100.0
Per cent. strong	91.7	55.7	45.9	44.5	75.0	60.0	......	......

RELATION OF PERIOD OF GESTATION TO VITALITY OR STRENGTH OF LAMBS.

In Table No. IV giving data concerning the vitality or strength of the whole number of lambs dropped during each of the twelve years over which this record extends may be found much interesting data. The range in percentage number of the strong and also of the dead lambs at birth is shown on Chart A. In studying this frequent reference should be made to the table where it will be seen that the very high percentage of strong lambs born on the 142d day of the gestation period may be accounted for in part at least by the comparatively small number of instances on which births occurred on this day of the period, consequently too much importance should not be attached thereto. The chart as well as the

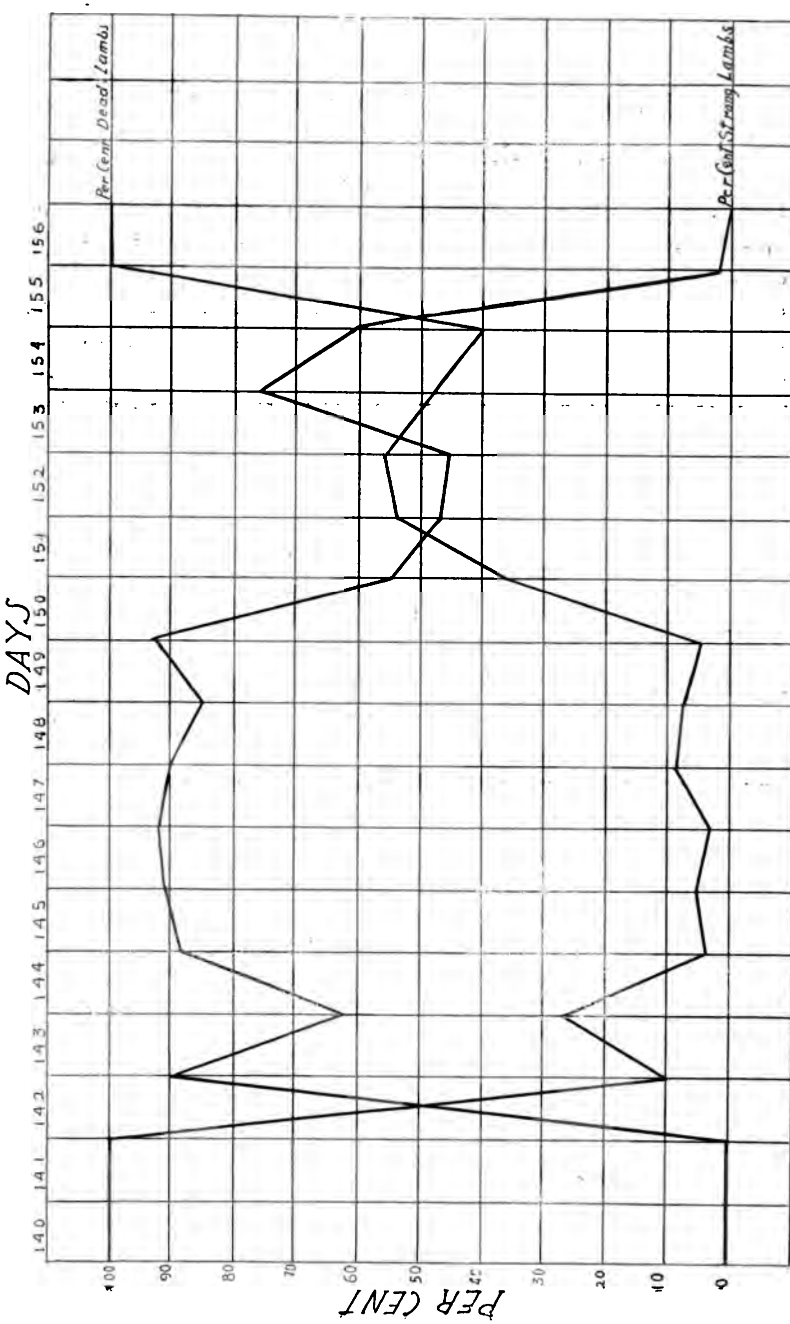

CHART A.—Showing the relation between the length of the period of gestation and condition of lambs at birth.

table, however, shows very conclusively that lambs dropped from 144 to 149 days after the service of the ewes are stronger and possessed of much greater vitality than when carried for either a shorter or a longer period. Of 45 lambs dropped on the 150th day after service 17, or 37.7 per cent., were born dead and of the 24 lambs dropped 151 days after the ewes were served 13, or 54 per cent., were still-born and a still greater per cent. of dead lambs were dropped on the 152d day after service. It must be borne in mind, however, in studying these data that in the case of lambs dropped several days before or after the regular or average period of gestation the number of examples are comparatively few in number, which accounts for the wide variation in percentage of dead or strong lambs noticed on successive days after the 149th and before the 143d day of the gestation period.

For the years of 1900, 1901 and 1902 very complete records were kept not only of the number, weight, and breeding of lambs dropped by each of the ewes, but careful observations were also made concerning the condition of each of the lambs as to their strength and vitality at birth. The results in averages of these observations with the records are given in Table No. V. The Southdown ewes represented in this work were all purely bred and recorded in the American Southdown Flock Book. The Shropshire ewes were not purely bred but all of them had five or more immediate crosses of pure breeding through the sires used so that for all practical purposes they may be considered as pure bred Shropshires. The Shrop-Merino crosses were sired by a pure-bred Shropshire ram in every case and out of American Merino ewes for the first cross and of their cross-bred descendants by Shropshire rams for succeeding crosses. The Dorset-Shrop crosses were sired by a pure-bred Dorset ram in most cases but in a number of instances a cross-bred Dorset-Shrop ram was used. The ewes in every case were cross-bred Dorset-Shrops, the result of crossing a pure-bred Dorset ram on grade Shrop ewes. In a few instances the ewes had two crosses of Dorset blood making them three-fourths Dorset and one-fourth Shropshire.

4

CONDITION OF LAMBS OF THE VARIOUS BREEDS AT BIRTH.

The data on this point for the three years mentioned shows that the Southdown ewes dropped 78 per cent. of strong lambs while the Shropshire ewes dropped 59 per cent. The Shrop-Merinos 73.4 per cent. and the Dorset-Shrops 60 per cent. of strong lambs, the latter being but a trifle ahead of the Shropshires. The Shrop-Merinos, however, have the smallest percentage of weak lambs which would in average vitality of lambs at birth, make them practically the equal of the Southdowns. The Shropshires, however, of the breeds and crosses mentioned show the least vitality in their lambs at birth.

PER CENT. OF TRIPLETS, TWINS, AND SINGLE LAMBS FROM EWES OF EACH OF THE VARIOUS BREEDS AND CROSSES.

The Shropshire ewes were found to be easily in the lead in percentage increase for the three years above mentioned with the Shrop-Merinos a close second. As 19 per cent. of the lambs dropped by Shropshire ewes were triplets this may in some measure account for the large percentage of weak lambs from the ewes of this breed though the Shrop-Merino ewes with 15 per cent. of triplet lambs had the smallest percentage of weak lambs of any of the breeds or crosses. None of the Southdown ewes gave birth to triplets though the ewes of this breed gave the largest percentage of twins of any breed or cross. It will also be noticed that 13.3 per cent. of the whole number of lambs dropped were triplets, 19.1 per cent. were singles, and 67.6 per cent. or over two-thirds of the whole number were twin lambs.

COMPARATIVE WEIGHT AT BIRTH OF SINGLE, TWIN, AND TRIPLET LAMBS OF EACH OF THE VARIOUS BREEDS AND CROSSES.

It is very apparent from the data presented in the accompanying table that single lambs are much larger at birth on the average than twins and that twins are much larger than triplets, the difference in average weight between single and twin lambs being 1.44 pounds and between single and triplet

lambs a difference of 2.16 pounds, yet from lamb feeding experiments conducted at this Station (16th Ann. Rep., p. 51), it was found that until weaning time twins made equally as good gains as single lambs.

PERCENTAGE OF WEAK, MEDIUM AND STRONG SINGLE, TWIN AND TRIPLET LAMBS OF EACH OF THE VARIOUS BREEDS.

As stated above, during the early years of our Station records a complete report was not made of the condition of the lambs at birth. All those that were dead when dropped or died within a few hours thereafter and all those with any constitutional weakness such as goitre, were noted and are considered as weak lambs in these records. All of the remainder are considered as strong lambs. The complete records on this subject were begun in 1899. After this time all dead, very weak or diseased lambs at birth had the condition carefully noted and recorded in the flock books and are considered as weak lambs in these records. Since complete records were established, all lambs showing marked vitality, vigor and activity at birth were classed as strong, and all those coming between the very weak, dead and diseased class and the very strong class, are grouped as a medium class.

Under these conditions we notice that in the single lambs from Shropshire ewes one hundred per cent. were strong. In the Shrop-Merino crosses 91.7 per cent. of the singles were strong and 8.3 per cent. were of medium strength. The Southdown lambs were notably either weak or strong; 20 per cent. weak, 8.3 per cent. of medium, and 58.3 per cent. of strong. The majority of the weak lambs in this breed was affected with goitre to a greater extent than in any of the other breeds or crosses. The Dorset-Shrop crosses show 33.3 per cent. weak, 8.3 per cent .of medium, and 58.3 per cent. of strong single lambs. This result is all the more surprising when we note the large percentage of strong twins in the lambs of this cross amounting as it does to 72.2 per cent. with only 5.6 per cent. of weak twins. It is apparent from the figures given in this table that the strength of the Shropshire lambs is affected much more seriously by an increased pro-

duction of twins and triplets than is any of the other breeds or crosses represented, though the difference is not very great between them and the Shrop crosses in this respect if twins only are considered. A very peculiar feature of this table is noted in the last column where the total percentages of weak,

TABLE NO. V.

Showing the number and per cent. of weak, medium and strong single, twin and triplet lambs from ewes of the various breeds and crosses.

	Shropshires.		Shrop-Merino Crosses.		Dorset-Shrop Crosses.		South downs.		Per Cent. of Total.
	No.	Per cent.	No.	Per cent.	No.	Per cent.	No.	Per cent.	
Weak	14	14.5	4	6.6	4	9.0	3	9.0	11.1
Medium	24	24.7	12	20.0	14	31.0	2	13.0	23.1
Strong	59	60.8	44	73.4	27	60.0	18	78.0	65.8
Single lambs	13	13.5	13	21.7	12	26.7	5	22.0	19.1
Twin lambs	66	67.5	38	63.3	30	66.6	18	78.0	67.6
Triplet lambs	18	19.0	9	15.0	3	6.7	......	......	13.3

	Shropshires.	Shrop-Merino Crosses.	Dorset-Shrop Crosses.	South downs.	Per cent. of Total.
Av. wt. of single lambs	9.43 lbs.	9.86 lbs.	8.52 lbs.	8.8 lbs.	9.15 lbs.
Av. wt. of twin lambs	7.62 lbs.	7.37 lbs.	8.09 lbs.	7.7 lbs.	7.69 lbs.
Av. wt. of triplet lambs	7.06 lbs.	6.24 lbs.	8.3 lbs.	....	6.99 lbs.
Per cent. of weak singles	....	....	33.3	20.0	18.4
Per cent. of weak twins	12.5	11.8	5.6	12.5	10.6
Per cent. of weak triplets	20.0	....	....	....	11.2
Per cent. of medium singles	....	8.3	8.3	....	2.2
Per cent. of medium twins	21.8	23.5	22.2	12.5	21.4
Per cent. of medium triplets	60.0	33.3	100.0	....	55.5
Per cent. of strong singles	100.0	91.7	58.3	80.0	79.4
Per cent. of strong twins	65.7	64.7	72.2	75.0	68.0
Per cent. of strong triplets	20.0	66.7	....	....	33.3

medium and strong singles, twins, and triplets respectively are compared. It will be seen that in the case of single lambs the percentage of very strong is appreciably greater than in the case of twins and triplets, while at the same time the percentage of weak lambs is also greater where singles are born than is the case with twins and triplets. From these observed peculiarities we must conclude that single lambs are apt to be either very strong or very weak, a large proportion being very strong. With twins, as compared with singles, we notice that there is a very large percentage of medium lambs. Where triplets are dropped, however, we find that only about one-third of the total number are very strong, over one-half are of medium strength and but a comparatively small percentage are very weak at birth. Since the percentage of very weak and dead lambs at birth is much greater in the case of single lambs than where twins and triplets are dropped, we may conclude that where ewes are well fed and are strong and vigorous, twins or even triplets from them are on the average possessed of as much vigor at birth as single lambs.

PERCENTAGE INCREASE OF LAMBS FROM EWES OF THE DIFFERENT BREEDS AND CROSSES FOR THE DIFFERENT YEARS.

In Table No. VI showing the per cent. of increase for the various years we find some very interesting data. We have given the data for each of the Shrop-Merino crosses separately in Table No. VII to show the marked increase in prolificacy as the percentage of Shropshire blood increased in the ewes. In the column giving the increase of the first cross, that is, where the lambs were first-cross and the ewes were pure-bred and high-grade Merinos, the per cent. of increase is only 126, while in the fourth cross the increase is 194 per cent. The greatest improvement, however, is noticed in the column for the second cross, where it will be seen the increase has advanced from 126 to 153 per cent. The Shropshires are found to be the most prolific breed, giving an average increase of 169 per cent. The cross-bred Dorset-Shrops are next with 162 per cent. increase; the cross-bred Shropshire-Merinos are third with 153 per cent., and the Southdowns with the lowest percentage of increase, namely, 151 per cent.

TABLE NO VI.—*Showing the average per cent. of increase of the different breeds for each of the years of the record. Also the average weight of the lambs dropped by the different breeds in the various years.*

YEAR.	SHROPSHIRES.				SOUTHDOWNS.				DORSETS.				TOTALS.				SHROP-MERINO CROSSES.				Age of r'm	Totals of Shropshires and crosses.	
	Ewes.	Lambs.	Per cent. increase.	Average weight.	Ewes.	Lambs.	Per cent. increase.	Average weight.	Ewes.	Lambs.	Per cent. increase.	Average weight.	Ewes.	Lambs.	Per cent. increase.	Average weight.	Ewes.	Lambs.	Per cent. increase.	Average weight.	Years.	Per cent. increase.	Average weight.
				lbs.				lbs.				lbs.				lbs.				lbs.			lbs.
1891	23	31	131	8.75	......	......	......	......	......	......	......	......	47	60	127	8.05	24	29	120	6.88	1	127	8.05
1892	24	43	165	8.36	2	3	150	7.7	9	16	177	7.90	42	70	166	8.32	7	8	114	9.	1	164	8.46
1893	15	21	140	9.56	1	2	200	7.6	4	5	125	7.36	31	43	138	9.13	11	15	136	9.33	1	138	9.46
1894	18	25	139	8.76	2	4	200	......	10	15	150	9 00	37	56	151	8.57	7	12	170	7.57	1	148	8.35
1895	24	38	158	8.7	2	2	100	......	16	35	218	......	54	93	172	8.6	12	18	150	8.35	1	156	8.61
1896	19	33	184	....	......	......	......	......	15	22	146	......	34	57	167	......	....	....	....	....	2	184	....
1897	23	40	174	8.35	3	4	133	7.9	20	28	140	9.3	59	92	156	8.65	13	20	153	7.75	3	167	8.3
1898	22	35	159	8.19	2	2	100	......	12	17	142	10.76	4[illegible]	77	160	8.72	12	23	191	8.03	1	170	8.12
1899	20	39	195	7.28	3	4	133	7.75	12	2[illegible]	183	9.1	46	83	180	7.97	11	18	163	8.16	2	184	7.53
1900	17	3[illegible]	194	7.63	3	5	166	8.5	14	22	157	8.62	44	75	170	8.13	10	15	150	8.41	2	175	7.87
1901	15	27	180	7.98	5	8	160	7.27	9	14	155	8.3	42	71	169	7.81	13	22	169	7.54	3	175	7.78
1902	19	37	191	7 9	6	10	166	8.05	7	12	171	7.99	44	82	185	7.92	12	23	191	7.88	3	193	7.89
Totals	236	401	....	8 13	29	41	......	7.86	128	203	......	8.92	52[illegible]	859	......	8.3	13[illegible]	203	....	8.04	....	....	8.14
Average per cent. increase	..	....	169	....	......	......	151	......	......	......	162	......	......	......	162	......	....	....	153	....	....	163	....

Average weight of lambs sired by yearling rams = 8.46 lbs.

Average weight of lambs sired by rams two years old and over = 7.86 lbs.

VARIATION IN PERCENTAGE INCREASE FOR THE DIFFERENT YEARS.

In the columns to the right of Table No. VI is shown the total percentages for the different years. Here we find that during the first six years from 1891 to 1896 inclusive the average increase from all of the ewes was 153 and for the last six years of the record the increase was 173 per cent. On the average 70 per cent. of the ewes bred each year were Shropshires or Shrop-Merino crosses and served by a Shropshire ram. A careful review of the record book discovered the interesting fact that for five of the first six years the Shropshire rams to which these ewes were bred were yearlings and that during the last six years the rams used were either two or three years old with but one exception when a yearling was used. To avoid complications in this matter we have decided to give the results of the breeding of the Shropshire rams only, as shown in the column giving per cent. of increase of the Shropshires and crosses for the various years. We found that by including the breeding record of Southdown and Dorset rams we had at times used a three-year-old Dorset for the Dorset ewes the same year that we had used a yearling Shropshire which would have tended to equalize any noticeable effect that might be attributable to the age of the ram if records of per cent. of offspring of two rams of different ages were included in the increase of any one year. When the lambs sired by the Shropshire rams only, are included we find that for the six years where the ewes were served by a yearling ram the average increase was 150 per cent. and for the six years, during three of which two-year-old and three three-year-old rams respectively were used, the average increase was 180 per cent. These data are quite at variance with the opinion commonly held by sheepmen generally to the effect that a well grown, vigorous yearling ram is at his best as a sire. It is also contrary to the belief held by many that the vigor of the sire has no apparent influence on the percentage of increase. It should, however, be known in this connection that only those ewes are included in these data that gave birth to lambs, the barren ewes, of which there

were one or two each year, are not included. No new families of Shropshire ewes were introduced during the period covered by these data, so that we could not attribute any of these results to the ewes' influence. In two of the instances where two and three year old rams were used, the same rams were used as yearlings.

TABLE No. VII.

Average per cent. increase and average weight of the lawbs dropped by the Shropshire-Merino ewes.

YEARS.	1st Cross.				2d Cross.				3d Cross.				4th Cross.			
	Ewes.	Lambs.	Per Cent. Increase.	Average weight.	Ewes.	Lambs.	Per cent. increase.	Average weight.	Ewes.	Lambs.	Per cent. increase.	Average weight.	Ewes.	Lambs.	Per cent. increase.	Average weight.
				lbs.				lbs.				lbs.				lbs.
1891	11	13	118	6.99	13	16	123	6.62	....	....	....	....	....	....	....	....
1892	7	8	114	9.	....	....	....	....	....	....	....	....	....	....	....	....
1893	3	4	133	9.07	6	9	150	9.05	2	2	100	11.1	....	....	....	....
1894	3	5	166	8.04	3	5	166	7.23	1	2	200	....	....	....	....	....
1895	4	5	125	....	5	9	180	8.35	3	4	133	....	....	....	....	....
1896	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
1897	....	....	....	....	5	8	160	....	6	8	133	....	2	4	200	7.75
1898	....	....	....	....	5	9	180	7.97	5	9	180	8.4	2	5	250	7.66
1899	3	3	100	9.93	2	4	200	8.22	4	7	175	7.76	2	4	200	7.6
1900	3	3	100	8.73	1	2	200	7.5	3	5	166	9.48	3	5	16	7.52
1901	2	3	150	8.26	2	2	100	10.6	4	8	200	7.3	5	9	180	6.84
1902	2	4	200	8.22	1	2	200	6.8	4	7	175	8.01	5	10	200	7.88
Totals	38	48	....	8.42	43	66	....	8.01	32	52	....	8.24	19	37	....	7.47
Av. per cent. increase	....	....	126	....	....	...	153	....	....	....	162	..	....	....	194	....

Another interesting feature of this table of results will be noticed in the columns giving the average weights of lambs for the different years. The average weight of the lambs bears a fairly constant relation to the per cent. of increase for the different years, but in an inverse ratio, that is, where the per cent. of increase is large, the average weight of lambs is small and vice versa. In noting the effect the age of sire has on average weight of lambs we find that the average of lambs sired by the six yearling rams was 8.46 lbs. and that the aver-

age weight of those sired by the two and three-year-old rams, was 7.86 lbs. We would, however, be inclined to attach much more importance to the ewes' influence in this case as we would naturally expect that where the percentage of increase was not as large that the average weight would be greater and give the ewes credit for this influence, especially as we have seen that a large percentage of the large single lambs were quite weak at birth.

TABLE No. VIII.

The effect of the age of ewes on per cent. increase and sex of lambs.

AGE.	2 years.		3 years.		4 years.		5 years.		6 years.		7 years		8 years	
	No.	Per ct.	No.	Per ct.	No.	Per ct.	No.	Per ct.	No.	Per ct.	No.	Per ct.	No.	Per ct.
Single lambs	62	44.6	30	31.9	21	30.4	14	23.5	9	33.3	6	60.	....	...
Pairs of twins	72	52.5	58	61.7	42	60.8	32	65.3	15	55.5	3	30.	2	....
Sets of triplets	4	2.9	6	6.4	6	8.8	3	6.2	3	11.2	1	10.	....	....
Rams	96	49.	75	51.	71	57.2	45	51.7	24	53.3	10	66.7	2	50
Ewes	100	51.	72	49.	53	42.8	42	48.3	21	46.7	5	33.3	2	50
Per cent. of increase..	158		174		178		177		178		150		.....	...

The average per cent. of increase by ewes of various ages is presented in Table No. VIII. In this we find the rate of increase for ewes of different ages bears a very close relation to the rate of increase noted from rams of dfferent ages. The two-year-old ewes gave an increase of 158 per cent., the three-year-old ewes an increase of 174 per cent., and the four, five and six-year-old ewes gave the greatest average increase, the per cent. of increase dropping again with the seven-year-old ewes to 150 per cent. The data presented in this table would also seem to indicate that a greater proportion of ram lambs are dropped by the older ewes, though this may be accidental, and more data should be gathered before definite conclusions can be drawn on this point.

In Table No. IX an attempt is made to show what effect if any a more or less extensive service of the ram may have

upon the offspring. Service rams at the Station were never allowed to run with the ewes during the rutting season, consequently we have no records bearing on the effect of extreme service, but the results of very careful service on a comparatively limited number of ewes will serve to show how disastrous excessive service might be. Our rams have always been well fed and in addition to other exercise were turned into the yards with the ewes morning and evening of each day during which time they quickly discovered the ewes at service. These were separated from the flock and only one service given each ewe except in rare cases when for some special reason two services were allowed with twelve hours intervening. Rarely was a ram required to serve more than three ewes in one day and then only after allowing some time to intervene between services. For the purpose of determining the effect of service upon the per cent. of offspring and also the effect upon size of lambs the ewes sent to the service of each ram during a season have been divided into groups of ten and the number and per cent. of lambs dropped, together with their average size, weight, and sex, is given in the various columns of Table No. IX. From this it will be seen that while the difference in percentage increase is not marked in the various groups for each ram, yet when the general average of the first group of ten ewes bred to the rams for the twelve years is taken, the increase is 171.4 per cent., the second group or from the 11th to the 20th ewes bred gave an average of 167.6 per cent. increase, the third group or from the 21st to the 30th ewes bred gave an average of 161.6 per cent. increase, or about 10 per cent. less than the first ten bred, while the fourth group or the 31st to the 40th ewes gave an average increase of only 140 per cent. or more than 30 per cent. less increase on the average than did the first group bred. Such striking results as these from rams where every care is taken to prevent excessive service indicate that much more serious results may be expected where rams are permitted to run at large with the ewes and may serve a single ewe many times at one period of heat.

TABLE No. IX.

Data showing the effect of service of ram on the percentage increase of lambs.

Number of Ram.	LENGTH OF SERVICE.	NUMBER. No.	NUMBER. Per ct.	SIZE. Av'ge.	SIZE. Large.	SIZE. Small.	SEX. Ram.	SEX. Ewe.
	1891.			Lbs.	Lbs.	Lbs.		
1	First. 10	14	140	7.01	10.6	4.1	*6	*2
	Second. 10	12	120	7 32	10	5.9	5	6
	Third. 10	12	120	....	....	....	6	6
	1892.							
2	First. 10	15	150	7.9	10.5	3.8	5	9
	Second. 10	16	160	8 76	11.8	5 5	8	8
	Third. 10	16	160	8 81	11.	6.3	10	6
	Fourth. 4	5	125	9.02	11.1	7.9	3	2
	1893.							
3	First. 10	16	160	9.53	13.	6 3	5	8
	Second. 10	14	140	9.4	12.7	6.1	10	4
	Third. 8	10	125	8.26	11.6	5.6	*3	5
	1894.							
4	First. 10	19	190	7.87	10.4	6.2	*7	7
	Second. 10	15	150	8 52	11.	6.8	6	6
	Third. 10	13	130	9.02	10.4	7.2	3	4
	1895.							
5	First. 10	16	160	8.61	9.4	8.1	6	9
	Second. 10	19	190	....	....	....	9	10
	Third. 10	16	160	....	....	....	6	10
	Fourth. 6	7	116	....	....	....	4	1
	1896.							
6	First. 10	19	190	....	....	....	11	8
	Second. 9	16	160	....	....	....	6	10
	1897.							
7	First. 10	17	170	9.69	11.7	7.7	13	4
	Second. 10	13	130	10.18	13.	7.6	4	9
	Third. 5	9	180	6.63	10.6	4.2	5	2
	1898.							
8	First. 10	17	170	8.2	12.2	5.6	7	6
	Second. 10	17	170	7.6	10.3	5 4	5	12
	Third. 10	18	180	7 96	10.1	6.5	9	9
	Fourth. 5	9	180	8.77	9.5	7.2	2	5
	1899.							
9	First. 10	18	180	7.61	11.5	5.1	8	7
	Second. 10	21	210	7.56	13.5	4.1	10	10
	Third. 10	20	200	7.33	13 8	3.	9	9
	1900.							
10	First. 9	16	177	7.95	12.6	3.8	8	8
	Second. 9	17	188	7.42	9 2	5.4	4	12
	Third. 9	15	166	8.3	10.5	6.2	8	7
	1901.							
11	First. 10	17	170	8.	11.3	5.3	8	8
	Second. 10	17	170	7.93	11.5	5.4	10	7
	Third. 7	12	171	6.73	9.7	4.5	5	4
	1902.							
12	First. 10	20	200	8.04	10.3	3 2	7	13
	Second. 10	21	210	7.63	10 6	4 6	10	10
	Third. 10	19	190	7.9	10.6	6.	6	12

* Sex of all the lambs not indicated.

TABLE No. IX—continued.

General averages.

	Number.		Size.			Sex.			
	No.	Per ct.	Av'ge.	Large.	Small.	Ram.		Ewe.	
			Lbs.	Lbs.	Lbs.	No.	Per ct.	No.	Per ct.
First lot	....	171.4	8.26	11.2	5.38	91	53	79	47
Second lot....	....	167.6	8.16	11.36	5.68	87	46	104	54
Third lot......	....	161.6	7.86	10.92	5.5	70	49	74	51
Fourth lot....	....	140.	....	....	....	....	....	....	....

The effect upon the average weight and size of the lambs dropped by ewes of the various groups is in about the same proportion as the per cent. of increase. The earlier lambs sired averaged the heaviest in weight at birth and the later groups the lightest. The table also shows a slight difference in favor of male lambs from the first group though this difference is not great enough to attach any special importance to it.

SUMMARY.

I. From the breeding records of 514 ewes at this Station we conclude that for such animals and conditions as ours the normal period of gestation ranges from 144 to 150 days after the date of service and that more ewes will lamb 146 days after service than at any other time.

II. There is no appreciable difference in the period of gestation for male and female offspring in sheep.

III. There is an apparent relation between the duration of the period of gestation and the period required for reaching maturity. Quick maturing breeds appear to carry their young for a shorter period than those breeds requiring more time to mature.

IV. Large lambs are on the average carried *in utero* for an appreciably longer period than small or medium lambs.

V. Lambs dropped before the 144th and after the 149th day of pregnancy are lacking in strength and vitality at birth.

VI. Shropshire ewes were more prolific than any of the

other breeds and crosses except the fourth cross of Shropshire rams on a Merino ewe foundation.

VII. From the data presented it is apparent that twins are the normal increase for ewes of the mutton type.

VIII. One year old rams are not so prolific as those two or three years old. Ewes also average a larger percentage of increase in lambs after they reach full maturity at three years of age until after they are six years old, when the rate of increase diminishes.

IX. The amount of service required, of the ram in breeding has an influence on the percentage increase in offspring of the ewes that produce lambs. Ewes bred early in the season of mating to a single ram, dropped a larger percentage of lambs than those near the latter end of the season.

THE COMPARATIVE VALUE AND EFFECT UPON THE LAMBS OF FEEDING VARIOUS GRAIN RATIONS TO PREGNANT EWES.

W. L. CARLYLE AND T. F. McCONNELL.

The results of experiments in feeding pregnant ewes, given in the 17th and 18th Annual Reports of this Station, show the effect of different rations of roughage when fed in connection with the same grain ration. This experiment, however. had another object in view, namely, a comparison of the value, and effect upon the lambs of different *grain* rations when fed with the same roughage ration to ewes during pregnancy.

Forty-eight ewes from the Station flock, available for this experiment, were divided into four equal lots, numbered I, II, III and IV. These four lots were made as uniform as possible with regard to the age, weight and breeding of the individuals composing them.

The grains available were shelled corn, whole oats, bran and dried brewers' grains.

"Dried brewers' grains"[1] are the ordinary "wet brewers' grains" with the excessive moisture removed by drying. This produces a concentrate that is rich in protein and is relished by animals after they become accustomed to it.

Lot I received ½ lb. shelled corn per ewe per day.

Lot II received ½ lb. whole oats per ewe per day.

Lot III received ½ lb. bran per ewe per day.

Lot IV received ½ lb. dried brewers' grains per ewe per day.

Each lot was fed its grain ration once daily.

[1] W. A. Henry, "Feeds and Feeding," pp. 136–137.

It was impossible to procure the dried brewers' grains as soon as we wished to start the experiment, therefore the ewes were fed a preliminary trial of two weeks. Lot IV, which should have received dried brewers' grains, receiving one-half pound bran and oats equal parts per ewe per day. On January 19th, 1902, having received the brewers' grains Lot IV were given their regular allowance, but at first they would not eat it. In a short time, however, they were eating the "grains" with as much avidity as any of the other lots were their grain ration.

In addition to their grain ration each lot received 2½ pounds corn silage and 2 pounds mixed hay per ewe per day. The silage was fed in feed-troughs in the barn and any that was not eaten was gathered up and weighed each day so as to determine the exact amount eaten by each lot. On every day that the weather would permit each lot was fed one-half its hay in an open air paddock so that the ewes would receive necessary exercise. As the hay was practically all eaten no account was kept of this part of the refuse of the roughage.

The tables show that nearly all the silage was eaten. For the whole period the largest amount refused by any one lot was 29.1 lbs. by Lot II and the smallest amount, 15.6 lbs. was refused by Lot IV.

COST OF RATIONS FED.

As practically all of the roughage fed the different lots was eaten the difference in the cost of keeping, if there was any, hinged on the value of the various grain rations.

The prices quoted on the different grain feeds below were those prevailing in Chicago at the time the experiment was being carried on, and are for purposes of comparison only.

Dried brewers' grains	$20 00 per ton.
Oats	30 00 per ton.
Bran	22 00 per ton.
Shelled corn	24 00 per ton.
Corn silage	2 00 per ton.
Hay (mixed)	10 00 per ton.

When we consult the tables to determine the difference in cost of keeping the various lots we find that the dried brewers'

grains was the cheapest, and whole oats the most expensive grain ration, with the difference of 19.6 cents per ewe for the period of twelve weeks. This is well worth looking after if just as good results are obtained by feeding the cheap ration.

If we compare the cost of the ration with the nutritive ratio of the different grains, we find that the dried brewers' grains with a nutritive ratio of 1 to 3.7, bran with a nutritive ratio of 1 to 3.7, shelled corn with a nutritive ratio of 1 to 9.8 and whole oats with a nutritive ratio of 1 to 6.2 are the cheapest in the order named, commencing with the dried brewers' grains.

CONDITION OF THE EWES DURING THE EXPERIMENT.

The health and condition of the ewes was satisfactory throughout the experiment. They were all pregnant and carried their lambs for the full term. They were weighed every two weeks and careful notes kept of the individual weights of the several animals.

The total gain in weight for the whole period for the different lots varied from 206 lbs. for Lot III fed bran, 231 lbs. for Lot II fed whole oats, 234 lbs. for Lot I fed shelled corn, to 244 lbs. for Lot IV fed dried brewers' grains. This shows a difference of 38 lbs. between the lowest and highest gain and cannot be considered a marked difference. It was not found necessary to change the amount or character of the rations of the various lots at any time during the experiment.

EFFECT OF THE DIFFERENT GRAIN RATIONS UPON THE AMOUNT OF WATER DRANK BY THE VARIOUS LOTS.

Mr. Frank Kleinheinz, Station Shepherd, under whose careful feeding this experiment was carried on, noticed that some of the lots drank more water than others. Acting upon this observation he weighed the amount of water given the different lots each day and made note of the weights. This was carried on for two weeks only, but in that time Lot I eating shelled corn with a nutritive ratio of 1 to 9.8 drank 822 lbs. of water, Lot II eating whole oats with a nutritive ratio of 1 to 6.2 drank 860.8 lbs. of water, Lot III eating bran with a nutritive ratio of 1 to 3.7 drank 908.8 lbs. of water, and Lot IV eating dried

LOT I.— *Shelled corn, corn silage, mixed hay.*

DATE.	Shelled corn.	CORN SILAGE. Given.	Refused.	Eaten.	Mixed hay.	Weights and gains.
	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.
January 3-10	42	210	7.7	202.3	168	1,749
January 17	42	210	6.6	203.4	168	57
January 24	42	210	.4	209.6	168	....
January 31	42	210	1.1	208.9	168	—27
February 7	42	210	.9	209.1	168	....
February 14	42	210	.8	209.2	168	99
February 21	42	210	.2	209.8	168	....
February 28	42	210	.5	209.5	168	37
March 7	42	210	.2	209.8	168	....
March 14	42	210	.1	209.9	168	55
March 21	42	210	.4	209.6	168	....
March 28	42	210	—.1	209.9	168	13
Total feed and gain	504	2,520	19 0	2,501.0	2,016	234
Cost of feed	$6 05	$2 52	....	....	$10 08	$18 65

LOT II.— *Whole oats, corn silage, and mixed hay.*

DATE	Whole oats.	CORN SILAGE. Given.	Refused.	Eaten.	Mixed hay.	Weight and gains.
	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.
January 3-10	42	210	7.0	203 0	168	1,762
January 17	42	210	9.0	201.0	168	51
January 24	42	210	5 3	204 7	168	....
January 31	42	210	4.4	205.6	168	21
February 7	42	210	.5	209.5	168	....
February 14	42	210	1.2	208.8	168	38
February 21	42	210	.3	209.7	168	....
February 28	42	210	.4	209.6	168	29
March 7	42	210	.3	209.7	168	....
March 14	42	210	.2	209 8	168	59
March 21	42	210	.3	209.7	168	....
March 28	42	210	.2	209.8	168	33
Total feed and gain	504	2,520	29.1	2,490.9	2,016	231
Cost of feed	$7 56	$2 52	....	....	$10 08	$20 16

LOT III.—*Bran, corn silage, and mixed hay.*

Date.	Bran.	Corn Silage.			Mixed hay.	Weights and gains.
		Given.	Refused.	Eaten.		
	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.
January 3-10	42	210	3.1	206.9	168	1,764
January 17	42	210	7.8	202.2	168	46
January 24	42	210	3 1	206 9	168	....
January 31	42	210	.8	209.2	168	8
February 7	42	210	.3	209 7	168	....
February 14	42	210	.1	209 9	168	43
February 21	42	210	.2	209.8	168	....
February 28	42	210	.2	209 8	168	35
March 7	42	210	.1	209.9	168	....
March 14	42	210	.2	209.8	168	56
March 21	42	210	.3	209.7	168	....
March 28	42	210	.1	209.9	168	18
Total feed and gain	504	2,520	16 3	2,503 7	2,016	206
Cost of feed	$5 54	$2 52	....	....	$10 08	$18 14

LOT IV.—*Dried brewers' grains, corn silage, and mixed hay.*

Date.	Dried brewers' grains.	Corn Silage.			Mixed hay.	Weights and gains.
		Given.	Refused.	Eaten.		
	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.
January 3-10	42	210	5.3	204.7	168	1,773
January 17	33.8	210	5.0	205.0	168	56
January 24	42	210	2.0	208.0	168	....
January 31	42	210	.8	209.2	168	6
February 7	42	210	.6	209.4	168	....
February 14	42	210	.8	209.2	168	51
February 21	42	210	.3	209.7	168	....
February 28	42	210	.3	209 7	168	53
March 7	42	210	.1	209.9	168	....
March 14	42	210	.1	209.9	168	67
March 21	42	210	.2	209 8	168	....
March 28	42	210	.1	209.9	168	11
Total feed and gain	495.8	2,520	15.6	2,504.4	2, 016	244
Cost of feed	$5 21	$2 52	....	....	$10 18	$17 81

Amount of water drank by the different lots for two weeks.

DATE.	LOT I. Fed shelled corn.	LOT II. Fed whole oats.	LOT III. Fed bran.	LOT IV. Fed dried brewers' grains.
	Lbs.	Lbs.	Lbs.	Lbs.
February 24	45.	37.	30.	41.
February 25	52.4	55.	64.	69
February 26	59.	48.7	69.2	87.8
February 27	76.9	87 8	100 8	88.8
February 28	60.6	53.	64.6	70.9
March 1	56.6	59.6	60.4	56.
March 2	51.5	48.	50.8	51.
March 3	49.4	53.5	50.4	47.2
March 4	59 5	59.6	48.9	54.3
March 5	63.	78.5	84.2	88.5
March 6	62.9	71.2	66.5	78.8
March 7	63.8	72.2	82.4	78.9
March 8	59.9	56.	52.9	68.5
March 9	61.5	80.4	83.7	79.1
Total amount	822.0	860.8	908.8	959.8

Table showing the milking qualities of the ewes at parturition.

	GOOD.		MEDIUM.		POOR.	
	No.	Per cent.	No.	Per cent.	No.	Per cent.
Lot I, fed shelled corn	4	33	3	25	5	42
Lot II, fed whole oats	3	25	5	42	4	33
Lot III, fed bran	4	33⅓	4	33⅓	4	33⅓
Lot IV, fed dried brewers' grains	10	83	2	17	....	....

Table showing the condition of lambs at birth.

	STRONG.		MEDIUM.		WEAK.		DEAD.	
	No.	Per ct.	No.	Per ct.	No.	Per ct.	No.	Per ct.
Lot I, fed shelled corn	8	67	2	17	1	8	1	8
Lot II, fed whole oats	10	83	2	17	....	....	....	....
Lot III, fed bran	7	58⅓	4	33⅓	1	8⅓	....	....
Lot IV, fed dried brewers' grains	10	83	1	8½	....	....	1	8½

LOT I.— *Shelled corn, corn silage and mixed hay.*

No. of ewe.	Breeding.	Period of gestation, in days.	Milk supply of ewe at parturition.	Weight and number of lambs.	Total weight.	Strength of lambs at birth.
				Lbs.	Lbs.	
13	Grade Shropshire	150	Good	7.5— 7.4	14.9	Weak.
69	1st cross Southdown-Shropshire	150	....	....	....	Strong.
82	Southdown	145	Good	9.5	9.5	Strong.
84	Grade Dorset............	146	Good	7.4— 7.0	14.4	Strong.
96	3d cross Shrop-Merino ..	147	Medium..	7.4— 7.1	14.5	Strong.
293	1st cross Shrop-Merino..	147	Poor	10.1— 6.4	16.5	Dead.
1554	Grade Shropshire	148	Medium..	7.2—10.6	17.8	Medium
1831	Grade Shropshire	147	Poor	10.6, 6.6—4.6	21.8	Strong.
1907	4th cross Shrop-Merino..	146	Medium..	6.2, 5.2—6.1	17.5	Medium
1921	1st cross Southdown-Shropshire	144	Poor	9.1	9.1	Strong.
1951	Grade Dorset............	144	Poor	8.4	8.4	Strong.
1959	Grade Shropshire	146	Poor	9.5— 9.6	19.1	Strong.

Average length of the gestation period:—146.7days.
Average weight of lambs:—7.79 lbs.

LOT II — *Whole oats, corn silage and mixed hay.*

No. of ewe.	Breeding.	Period of gestation, in days.	Milk supply of ewe at parturition.	Weight and number of lambs.	Total weight.	Strength of lambs at birth.
				Lbs.	Lbs.	
7	4th cross Shrop-Merino .	146	Medium..	9.3—9.2	18.5	Strong.
33	Grade Shropshire	147	Good	8.0	8.0	Strong.
37	4th cross Shrop-Merino.	148	Medium..	8.9—8.6	17.5	Strong.
62	Grade Shropshire	146	Medium..	10.2	10.2	Strong.
67	Grade Dorset............	142	Poor	5.3	5.3	Medium.
117	2d cross Shrop-Merino...	146	Poor	7.4—6.2	13.6	Medium.
354	1st cross Shrop-Merino .	149	Poor	9.2—7.2	16.4	Strong.
1472	Grade Dorset	144	Good. ...	9.1—8.5	17.6	Strong.
1576	Grade Shropshire.......	149	Medium..	7.8—7.2	15.0	Strong.
1832	Grade Shropshire.......	146	Poor	7.7—6.8	14.5	Strong.
1858	Southdown..............	145	Good.. ..	7.8—8.0	15.8	Strong.
1961	Grade Shropshire	146	Medium..	9.5—9.0	18.5	Streng.

Average length of gestation period:—146.2 days.
Average weight of lambs:—8.14 lbs.

LOT III.—*Bran, corn silage and mixed hay.*

No. of ewe.	Breeding.	Period of gestation, in days.	Milk supply of ewe at parturition.	Weight and number of lambs.	Total weight.	Strength of lambs at birth.
				Lbs.	Lbs.	
49	3d cross Shrop-Merino ..	149	Good	8.8—7.0	15.8	Weak.
52	Grade Southdown.......	145	Good	9.2	9.2	Strong.
68	Grade Shropshire	146	Medium.	6.0—6.6	12.6	Strong.
95	3d cross Shrop-Merino ..	150	Poor	9.2	9.2	Strong.
98	1st cross Shrop-Oxford..	146	Medium ..	8.9—8.5	17.4	Medium.
101	Southdown	144	Good	8.7	8.7	Strong.
104	Grade Shropshire	147	Good	6 5—5.9	12.4	Strong.
107	Grade Shropshire	145	Poor	6 2	6.2	Strong
114	Grade Dorset............	144	Medium ..	8.6—6 0	14.6	Medium.
1546	Grade Shropshire	148	Medium ..	8.9—7.9—6.5	23.3	Medium.
1859	Southdown	144	Poor	9.2—7.6	16.8	Strong.
1902	Grade Shropshire	148	Poor	8.0—7.7	15.7	Medium.

Average length of the gestation period:—146.3 days.
Average weight of lambs:—7.69 lbs.

LOT IV.—*Dried brewers' grains, corn silage and mixed hay.*

No. of ewe.	Breeding.	Period of gestation, in days.	Milk supply of ewe at parturition.	Weight and number of lambs.	Total weight.	Strength of lambs at birth.
				Lbs.	Lbs.	
8	4th cross Shrop-Merino .	146	Good	8.1— 7.6	15.7	Strong.
28	4th cross Shrop-Merino .	145	Good	9 6	9.6	Strong.
40	Grade Southdown.......	147	Good	10.7	10.7	Strong.
64	Grade Dorset............	144	Good	8.3— 8.3	16.6	Strong
76	Southdown	145	Good	7.0— 7.2	14.2	Strong.
99	1st cross Shrop-Oxford..	146	Medium ..	10.4	10.4	Strong
108	Grade Shropshire	146	Medium ..	9.7— 9.4	19.1	Medium
119	Grade Shropshire	145	Good	10.3	10.3	Strong.
1469	Southdown	146	Good	7.6— 7.9	15.5	Strong.
1940	Grade Shropshire	144	Good	6.8—3 2—6.4	16.4	Dead.
1956	Grade Shropshire	145	Good . ..	8 1— 7.3	15.4	Strong.
1960	3d cross Shrop-Merino ..	148	Good	9.1— 8.0	17.1	Strong.

Average length of gestation period:—145 6 days.
Average weight of lambs:—8.14 lbs.

brewers' grains with a nutritive ratio of 1 to 3.1 drank 959.8 lbs. of water. In other words, the narrower the ration the more water drank by the animals consuming it. This phase of the experiment was not carried on long enough to draw very definite conclusions, except that, in this case, for this length of time, the amount of water drank corresponded very closely to the nutritive ratio of the feed consumed.

EFFECT UPON THE PERIOD OF GESTATION AND MILK SUPPLY OF THE EWES AT PARTURITION.

The length of the period of gestation averaged 146.6 days for the whole number of ewes and varied in the different lots from 145.6 days in Lot IV, which received the narrowest ration, to 146.6 days in Lot I, which received the widest ration. This is quite a wide difference to exist between two lots of ewes that were so equally divided in every way, however, it probably was only accidental.

The milk supply of the ewes at parturition is described by dividing their condition in this respect at that time into three classes, viz., good, medium, and poor.

When we consult the following tables we find that in Lot IV only, fed dried brewers' grains, is there a preponderance of ewes with a "good" milk supply and none at all in the "poor" class, or ten ewes with a good supply of milk, two with a medium supply and none with a poor supply. This condition is not equalled nor even approached by any of the other lots where we find from four to five in the "poor" class and fully as many in the medium class. In other words, in Lot IV 83 per cent. had a "good" supply of milk at parturition, while in the other lots from 25 per cent. to 33 per cent. only had a "good" supply at that time, the other 66 to 75 per cent. being about equally divided between the "medium" and "poor" class.

EFFECT UPON THE LAMBS.

To study the effect of the different grain rations upon the lamb crop we take into consideration the weight and condition of the lambs at birth, leaving out the number, as impregnation had already taken place before the experiment began. For this purpose we will observe the condition of the lambs at birth as

though they were divided into four classes, viz., strong, medium, weak, and dead. Each lamb was weighed at birth and note made of its condition.

Upon referring to the tables we find that the average weights of the lambs in Lots II and IV were the highest, being 8.14 lbs. for each lot. Lot I comes next with an average weight of 7.79 lbs. and Lot III last with an average weight of 7.69 lbs. Then when we investigate the *condition* of the lambs we find those in Lots II and IV are again ahead with the largest number of lambs in the "strong" class. These two lots both have ten ewes or 83 per cent. that dropped "strong" lambs. Lot II had the two remaining ewes or 17 per cent. drop their lambs in the "medium" class and the other one in the "dead" class, which therefore gives Lot II a slight advantage.

SUMMARY.

In summarizing the results of this experiment we find:

1st. That dried brewers' grains was the cheapest grain ration, with bran, shelled corn, and oats following in the order named.

2nd. That any of the above mentioned grain rations when fed in connection with a roughage ration of 2½ lbs. of corn silage and 2 lbs. mixed hay per ewe per day was quite satisfactory so far as the physical condition of the ewes was concerned.

3rd. The results would seem to indicate that the ewes fed the rations containing the largest amount of protein drank the largest amount of water.

4th. When the milk supply of the ewes at parturition is considered, we find that the grain ration of dried brewers' grains fed Lot IV produced by far the best results.

5th. Taking into consideration the size and strength of the lambs at birth, we find that the ration of whole oats fed Lot II and dried brewers' grains fed Lot IV produced the strongest and heaviest lambs, with the results slightly in favor of Lot II.

6th. Corn silage in connection with hay continues to meet with approval as a roughage ration for pregnant ewes in winter.

In conclusion, it would seem, that to arrive at more definite results along this line, it would be better to have the experimental feeding period extend over a greater portion of the time that the young lamb is dependent upon its dam for existence.

THREE TYPES OF MARKET SHEEP.

W. L. CARLYLE.

A surprising thing in connection with the live stock business of the country is the apparent ignorance on the part of the breeders and feeders concerning the type, quality and condition of the animals most desired and that command the highest market prices. A careful review of any of the leading live stock market reports will serve to disclose the fact that a very large proportion of the animals sold do not bring more than two-thirds as much per hundred weight as the choice lots sold. Since there is such a marked discrimination against those classes that are not especially desired by the consumer, it would seem that there is a great need among feeders for some exact knowledge as to what constitutes the highest type of carcass demanded by the consumer in the various classes of live stock.

The accompanying cut of a photograph showing cross-sections at the fifth rib of the carcasses of three sheep will serve to illustrate some of the reasons why there is such a marked discrimination in prices in the various grades of sheep on the market.

The central figure in the cut shows the fifth rib of the carcass of a lamb eight months of age that weighed when slaughtered 112 pounds. While this is a trifle over the weight most desired, yet a lot of lambs of the quality of this one would have commanded the very highest price.

The figure at the top of the cut represents the fifth rib of the carcass of a sheep that was twenty months old, and weighed 218 pounds when slaughtered. The animals represented by these two figures were bred on the University farm,

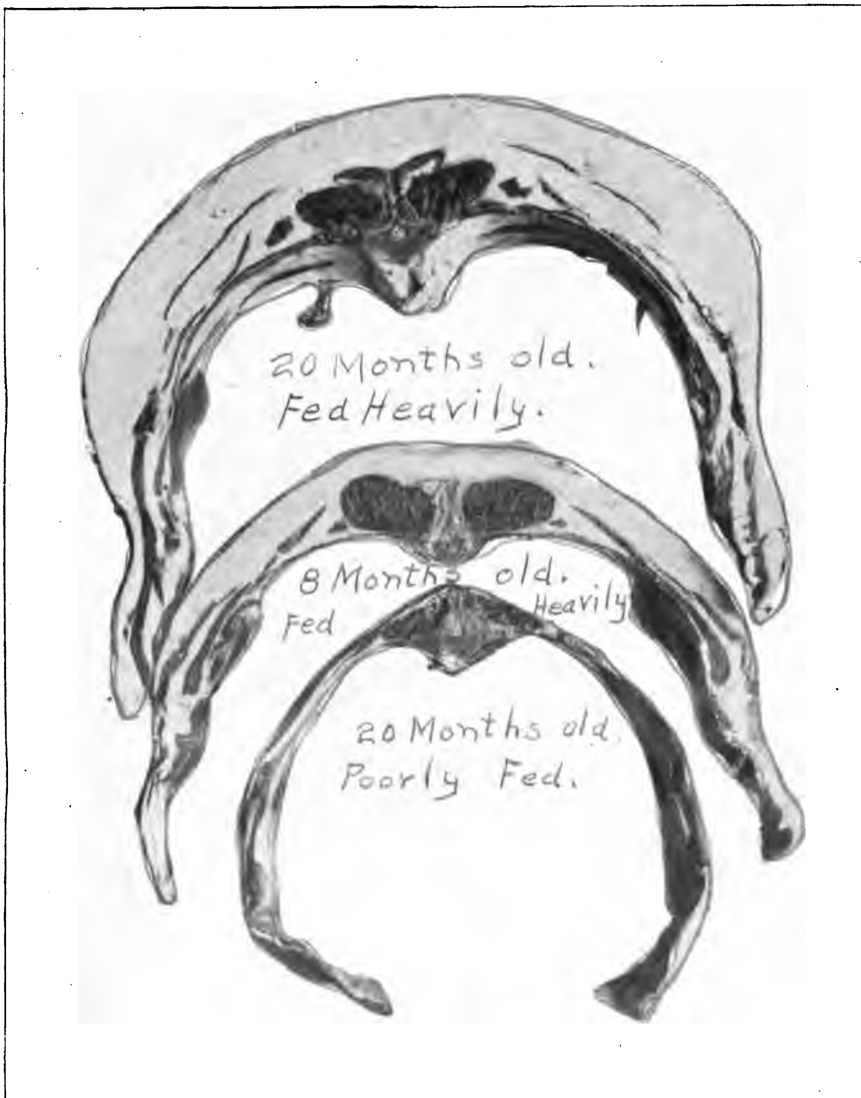

FIG. 11.—Cross-sections at the fifth rib of three carcasses of sheep showing the development of muscle and fat.

were sired by the same ram and out of ewes that were half-sisters. It would be hardly possible to find two animals more nearly similar in all points than these except the difference in age and weight. Both had been fed all they would eat almost from birth and had received the same kinds of feed and treatment generally. The older and larger sheep had been fed twelve months longer than the younger and smaller one, and yet, as the photograph of these cross sections shows, the amount of lean meat or muscle is actually less in the carcass of the larger and older sheep. This can only be explained by stating that there has been a fatty degeneration of the muscular fiber as a result of the long period of forced feeding on rich, carbonaceous feed. The result, therefore, of a full year's feeding was merely to add a great amount of fatty tissue, almost worthless from an edible standpoint, to the outside of the carcass of the older animal, and actually lessened the prime edible portions found in the lean meat or muscle. The local market made a difference of $1.00 per hundred live weight in the prices paid for these two sheep in favor of the younger animal, the dealer afterwards stating that the smaller carcass was much more profitable than the larger one even at that difference in price. In the case of the larger sheep weighing 218 pounds, we received four cents per pound or $8.72; the smaller one weighing 112 pounds was sold for five cents per pound, or $5.60, leaving a difference of $3.12 to pay for a full year's feeding, during all but two and one-half months of which a liberal grain ration supplemented by roots, clover, hay, etc., was fed.

The figure in the lower part of the cut represents a class of sheep that is very much less to be desired than either of the others. The fifth rib as represented in the cut was secured from the carcass of a sheep in a local dealer's shop where it was suspended from a hook adjoining the two carcasses mentioned. The butcher after making careful inquiry stated that this sheep was about 20 months old and that when it came to the slaughter house from the farmer from whom purchased, it was clearly evident that it was a well bred grade Shropshire as the other two sheep were, and was said to have been

sired by pure bred Shropshire ram as they were. While the effect of liberal long-continued feeding for 20 months has been shown to be a poor policy where highest quality of edible meat and best market price is to be obtained we here see the disastrous results upon the carcass where long-continued poor feeding is practiced. Notice the shriveled and shrunken condition of the muscles of the back in this carcass as compared with those above it. It scarcely seems credible that the lower figure is a section of a sheep 20 months of age while the middle one is 12 months younger or only 8 months. The dealer paid at the rate of $2.50 per hundred weight for this animal and found it much dearer meat than that obtained from the animal of the same age that had been over fattened. The inference to be drawn from this illustration is clear. In the case of the very large and over fattened sheep there was a direct loss in keeping this animal the additional twelve months not only in the feed consumed but in the reduced value of the meat obtained from the carcass. There must also have been a serious loss to the farmer who fed the very poor sheep for twenty months and sold it for just one-half the price per hundred weight that it might have been sold for had it been well fed until eight months old and then marketed.

INVESTIGATIONS OF METHODS OF MILKING.*

F. W. WOLL.

The work of milking does not on many farms receive the attention which its importance merits; many farmers look upon it as a necessary evil; as a work that has to be attended to in order to relieve the cows and to furnish the raw-material upon which they largely depend for cash outlays. The object of the milking is quite generally considered merely to obtain all the milk in the udder of the cow at the time of milking.

Another way of looking upon the work of milking has, however, come forward during late years, especially among dairymen and breeders of dairy cattle, viz., as a means of gradually improving the animal as a milk producer. It has been found that a better flow of milk during the lactation period is maintained by careful milking and this is continued for a longer time than when no particular attention is given to the work. The work of milking from this point of view is as important as any on the dairy farms and nobody can do it properly but persons endowed with a good share of intelligence, patience and conscientiousness. It goes almost without saying that when the milker brings such qualifications to his work, it will be highly respected and its importance appreciated as it should be, by himself as well as by those about him.

The amount of accurate information available to cow owners as to the need of care in milking and the best methods of milking is very limited and seems out of proportion of that furnished on other topics connected with the dairy cow. During the past year or two the subject of milking has received considerable

*This article is a resume of Bulletin No. 96 issued by this Station. The reader is referred to this bulletin for a complete account of the investigations here reported.

attention in the Scandinavian countries, especially in Denmark, where dairying, as is well known, is a most important industry. This has primarily beeen caused by the publication of a new method of milking worked out by a Danish veterinarian, Dr. J. Hegelund, of Ladelund Dairy School, Denmark.

The new method consists in continuing ordinary milking by a set of manipulations of the udder, which will bring down the last traces of milk contained therein. Dairymen know that many cows will give down very slowly the last portions of their milk, and thin streams of milk may generally be obtained for a considerable time after a full flow has ceased; by a few manipulations of the udder this residual milk may readily be brought down in a couple of minutes' time, and more milk will as a rule be obtained in this way than is possible by the ordinary "stripping" method. Since the milk thus secured is very rich, being of the same character and composition as "strippings," the amount of additional butter fat obtained is considerably greater than might be supposed from the quantity of milk brought down.

The Hegelund method differs from any of the ordinary methods of rapid, dry and thorough milking, mainly therein that in this method the udder is completely emptied by a set of manipulations after a full flow of milk has ceased. These manipulations are three in number and may be briefly described as follows:

DESCRIPTION OF THE MANIPULATIONS IN THE HEGELUND METHOD OF MILKING.

First Manipulation.—The right quarters of the udder are pressed against each other (if the udder is very large, only one quarter at a time is taken) with the left hand on the hind quarter and the right hand in front on the fore quarter, the thumbs being placed on the outside of the udder and the four fingers in the division between the two halves of the udder. The hands are now pressed toward each other and at the same time lifted toward the body of the cow. This pressing and lifting is repeated three times, the milk collected in the milk cistern is then milked out, and the manipulation repeated until no more milk is obtained in this way, when the left quarters are treated in the same manner. (See Fig. 12, a and b.)

FIG. 12a.—First manipulation of udder, right quarters. FIG. 12b.—First manipulation, left quarters.

Fig 13a.—Second manipulation, right fore quarter.

FIG. 13b.—Second manipulation, right hind quarter.

FIG. 13c.—Second manipulation, hind quarters.

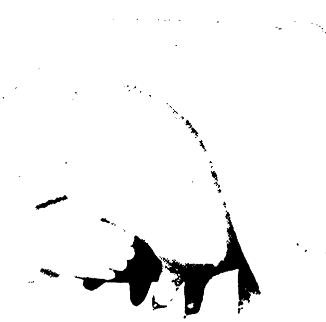

FIG. 14.—Third manipulation.

Second Manipulation.—The glands are pressed together from the side. The fore quarters are milked each by itself by placing one hand, with fingers spread, on the outside of the quarter and the other hand in the division between the right and left fore quarters; the hands are pressed against each other and the teat then milked. When no more milk is obtained by this manipulation, the hind quarters are milked by placing a hand on the outside of each quarter, likewise with fingers spread and turned upward, but with the thumb just in front of the hind quarter. The hands are lifted and grasp into the gland from behind and from the side, after which they are lowered to draw the milk. The manipulation is repeated until no more milk is obtained. (See Fig. 13, a, b and c.)

Third Manipulation.—The fore teats are grasped with partly closed hands and lifted with a push toward the body of the cow, both at the same time, by which method the glands are pressed between the hands and the body; the milk is drawn after each three pushes. When the fore teats are emptied, the hind teats are milked in the same manner. (See Fig. 14.)

The various steps gone through with and further details concerning this method of milking will be considered when the experimental data in this line have been presented.

A. MILKING EXPERIMENTS WITH COWS IN THE UNIVERSITY DAIRY HERD.

I. A PRELIMINARY EXPERIMENT.

The first work undertaken was to ascertain what results the method would give with the cows in our University dairy herd. In this preliminary work I was assisted by my colleague, Professor Carlyle, who has furthermore throughout the investigation freely given valuable help and suggestions. As soon as the regular milkers were done milking a cow, Professor Carlyle secured the additional amount of milk that could be drawn by the manipulation method described above. The cows were of course supposed to be milked clean in all cases by the regular milkers. The results given in the following table show the weights of milk obtained by the regular milkers and of

residual milk ("after-milk") by the manipulation method. Both lots of milk from each cow were sampled and analyzed separately for their fat contents; the trial was made with ten cows on the evening of June 3d and on the morning of June 4th.

Regular and residual milkings, June 3, P. M., and June 4, A. M.

NAME OF COWS.	MILK, LBS		PER CENT. FAT.		FAT, LBS.		TOTAL.		Fat increas'd, per cent.
	Regular.	Residual.	Regular.	Residual	Regular.	Residual.	Milk.	Fat.	
Belle	22.4	3.45	3.48	7.0	.78	.24	25.85	1.02	30.8
Pauline	23.5	3.55	3.53	7.6	.83	27	27.05	1.10	32.5
June	18.2	1.15	3.90	9.6	.71	.11	19.05	.82	15.5
Gold	20.2	1.55	6.73	10.3	1.36	.16	21.75	1.52	11.8
Brownie	13.4	1.25	5.45	8.0	.73	.10	14.65	.83	13.7
Campbell	32.7	1.00	4.53	15.0	1.10	.15	33.70	1.25	13.6
Alma	28.8	2.35	2.95	6.0	.85	.14	31.15	.99	16.5
Chloe	27.8	2.95	3.67	9.1	1.02	.27	30.75	1.29	26.5
McGeoch	44.5	1.70	3.42	8.8	1.52	.15	46.20	1.67	9.9
Dorine	19.2	1.40	5.36	15.0	1.03	.21	20.60	1.24	20.4
Total	250.7	20.35	.....	.....	9.93	1.80	271.05	11.73	.....
Average	25.07	2.04	.....	.....	.99	.18	27.11	1.17	18.1
Average per cent. fat	.....	.....	3.96	8.85	.....	.....	.....	4.33	.....
Average increase, in per cent.	.....	8.1	.....	.....	.....	18.1	.....	.....	.....

The percentages of fat given in the table are calculated from the sum of the amounts of milk and fat produced at the two milkings in case of the individual cows. It will be noted that a considerable increase in both milk and fat was obtained by the process of after-milking, viz., the yield of milk of 250.7 lbs. from the ten cows was increased by 20.35 lbs., or 8.1 per cent., while the production of fat was increased from 9.93 to 11.73 lbs., *i. e.,* 1.80 lbs., or 18.1 per cent.

The cows gave down from 1.00 to 3.55 lbs. of milk by the manipulation method, after the regular milkers had secured their usual mess of milk. The amount of fat obtained in the after-milking varied from .10 to .27 of a pound, or, calculating the gain in per cent. of fat of the regular milking, from 9.9 to 32.5 per cent.

Comparing the figures for the two milkings for the different cows, the following results will prove of interest:

	EVENING.		MORNING.	
	Milk.	Fat.	Milk.	Fat.
Regular milking, lbs	130.1	5.09	120.6	4.84
After-milking, lbs	10.20	.99	10.15	.81
Increase, per cent	7.8	19.5	8 4	17.4
Average per cow, after-milking, lbs.	.51	.10	.48	.08

The total amount of milk in the evening milking obtained by the manipulation of the udder was 10.2 lbs. (gain, 7.8 per cent.), and that in the morning milking, 10.15 lbs. (gain, 8.4 per cent.). In the same manner the total production of fat by the ten cows was increased by 19.5 per cent. in the evening milking, and by 17.4 per cent. in the morning milking.

The magnitude of these results was as much of a surprise to Prof. Carlyle and myself as to the three regular milkers. The latter knew nothing about the trial being conducted, but could not help finding out before many cows had been milked, that their work in some way was being checked up. The cows on the experiment were kept under as uniform conditions as possible before and after the trial as regards feed and care; it is hardly necessary to give detailed information on these points here, or as to the cows on this experiment. As to stage of lactation, breed and age of cows, see page 81.

The milk record of the University herd shows that the ten cows on the day following, viz., on 4 P. M. and 5 A. M., gave in all 260.7 lbs. of milk, about ten pounds more than on the day of the trial, seven cows giving more milk and three less. Separate tests of the milk of the ten cows were not made on this day. Fifteen other cows in the herd which were milked in the ordinary way on both days gave the following yields: June 3d to 4th, 343 lbs.; June 4th to 5th, 353.7 lbs., six cows going up in milk on the second day, eight going down, and one giving the same amount both days. The change in the milk with these cows therefore went in the same direction as with those on

the trial, with some difference in favor of the cows that were after-milked. These facts fail to show that the thorough emptying of the udders of the cows on the experiment had any tendency to reduce the amount of milk given by the cows on the following day, as might be expected to be the case. This question will be further considered when more data on this point have been presented.

II. SECOND MILKING EXPERIMENT.

On account of the striking results obtained in this preliminary trial, it was decided to conduct a more extended experiment with cows in our University herd in order to decide the question whether or not the large increase obtained by the method of after-milking would gradually disappear when the method was practiced for a longer period; it is, of course, entirely feasible that the cows might at first readily respond to this treatment and later on accommodate themselves to the same so that no marked results would be obtained by after-milking.

The plan of the second experiment was as follows: Three lots of cows of eight each, as uniform as possible as to period of lactation, age, breed, production of milk and butter fat, etc., were arranged for. Of these, Lot I was after-milked during the first and fourth weeks of the experiment, Lot III was after-milked during the second and fifth weeks, Lot II was after-milked every other day during the first two weeks and the last two weeks. During the third week the cows in Lot I, at the suggestion of Prof. Carlyle, were "stripped" for three minutes after the regular milkings were finished, while Lot II was treated in the same way every other day. The object of introducing this trial was to compare the systematized manipulation method with simple stripping for a similar length of time.

The after-milking on the experiment was done by the herdsman of the University herd, Mr. J. R. Danks, while the sampling and testing was generally done by Mr. R. T. Harris, one of our supervisors of dairy tests. The success of the experiment was due in a large measure to the conscientious and careful work done by these men. The tests made were frequent:.

checked up by the writer, who is responsible for all calculations and for the book-keeping in connection with the experiment, as well as for the deductions drawn from the results obtained.

The names of the cows included on the experiment are given in the following table, with other information in regard to these which has a bearing on this experiment.

Description of cows on experiment.

Lot.	Name.	Breed.	Age.	In milk June 10	Due to calve.	Yield June 4-11. Milk.	Yield June 4-11. Fat.	Per cent. fat.	Milker.
			Years.	Days.	Days.	Lbs.	Lbs.		
I	Mollie	Gr. Shorthorn	3	200	271	165.1	5.61	3.4	I
I	Belle	Gr. Shorthorn	8	73	287	165.2	5.45	3.3	I
I	Mary	Guernsey	2	137	234	91.7	4.40	4.8	I
I	McGeoch	Gr. Holstein	5	119	248	338.8	10.17	3.0	II
I	Alma	Holstein	6	290	195	206.9	6.08	2.95	II
I	Rilma	Gr. Jersey	3	83	308	147.7	7.68	5.2	II
I	Dora	Gr. Guernsey	7	156	276	184.5	9.04	4.9	III
I	Laura *	Jersey	7	500	57	95.5	4.97	5.2	III
II	Princess	Gr. Shorthorn	4	218	182	134.3	5.38	4.0	III
II	Pauline	Gr. Shorthorn	8	191	208	170.2	6.21	3.65	II
II	Chloe	Holstein	6	270	176	218.1	7.20	3.3	I
II	Lady	Gr. Red Polled	6(?)	307	123	192.1	7.49	3.9	II
II	Dorine	Gr. Guernsey	3	148	268	141.7	6.94	4.9	I
II	Ella	Gr. Guernsey	9	86	272	236.3	10.63	4.5	III
II	Brownie	Jersey	5(?)	270	208	108.4	5.90	5.45	III
II	Elsie	Gr. Jersey	3	106	272	128.6	6.23	4.85	I
III	Maud	Gr. Shorthorn	8	192	227	236.5	8.75	3.7	II
III	June	Gr. Shorthorn	3	269	200	139.8	5.10	3.65	I
III	Joe	Holstein	3	308	149	186.0	6.14	3.3	II
III	Donation	Gr. Holstein	6	163	198	212.5	6.80	3.2	III
III	Bessie	Gr. Guernsey	10	288	126	153.2	7.05	4.6	III
III	Muriel	Gr. Guernsey	3	84	292	145.6	8.30	5.7	I
III	Gold	Jersey	10	270	238	148.3	9.34	6.3	II
III	Roba	Gr. Jersey	5	105	252	199.1	9.96	5.0	III

* Dixie (substituted for Laura after 3d week), grade Shorthorn, age 3 years, 146 days in milk (on June 10), due to calve in 137 days; milk, 110.4 lbs.; fat, 4.42 lbs; 4.0 per cent. fat.

The milking of the cows was done in the following manner: As soon as the regular milker had milked a cow clean, the herdsman sat down to after-milk her; both lots of milk were at once weighed and sampled. In exceptional cases, there was a delay of a minute or two before the after-milking could begin, but so far as could be observed, the lapse of a limited interval of a few minutes did not have any tendency to give an increased quantity of milk in the after-milking. During the last three weeks of the experiment composite samples of the regular milk and after-milkings from each cow were taken, instead of separate samples.

The production by the different lots of cows for each week of the experiment is given in the following summary tables. In the first table the data for production of milk and fat placed in the columns headed "Regular Milking," were obtained during the weeks (*days* for Lot II) when the cows were not after-milked, if there are no figures on the same line in the columns headed "Residual Milking." The data obtained when after-milking was practiced are shown in the table for each week (total for alternate days, in case of Lot II), the quantities of milk secured in the regular milking and the after-milking being given separately.

Summary data obtained on main experiment.

Lot.	Week.	Regular Milking.			Residual Milking.			Total.		
		Milk.	Fat.	Fat.	Milk.	Fat.	Fat.	Milk.	Fat.	Fat.
		Lbs.	Lbs.	Per ct.	Lbs.	Lbs.	Per ct	Lbs.	Lbs.	Per ct.
I.....	1	1336.6	53.94	3.89	67.55	4.92	9.1	1454.15	58.86	4.03
	2	1377 8	53.76	3.90	....	....	....	1377.8	53.76	3 90
	4	1100.4	43 98	4.00	50.55	3.94	7.79	1150 95	47.92	4.16
	5	1170.6	46.82	4.00	....	....	....	1170.6	46.82	4.00
II ...	1 & 2	1313.2	54.06	4.12	....	....	....	1313.2	54.06	4.12
		1303.8	54 23	4.16	57.95	5.53	9.54	1361.75	59.76	4.39
	4 & 5	1081.1	46.43	4.29	....	....	....	1081.1	46.43	4.29
		1034.5	46.45	4.28	52.65	4.80	9 11	1137.15	51.25	4.51
III ..	1	1424.1	60.15	4.07	....	....	....	1424.1	60.15	4.07
	2	1396.9	58.10	4.16	61 45	5.25	8.54	1458 35	63 35	4.34
	4	1199.3	51 64	4.30	....	....	....	1199.3	51.64	4.30
	5	1220.3	52.29	4.29	48.65	4.08	8.38	1270.75	56.37	4.44
Total	1 & 2	4115.1	167.97	4.08	....	....	....	4115.1	167.97	4.08
		4087.3	166.27	4.07	186.95	15.70	8.40	4274.25	181.97	4.26
	4 & 5	3451.0	144 89	4 20	....	....	....	3451 0	144.89	4.20
		3405.2	142.72	4.19	151.85	12.82	8.45	3558.85	155.54	4.37
	1-5	7563.1	312.86	4 14	....	....	....	7566.1	312.86	4.14
		7492.9	308.99	4.12	338.8	28.52	8.42	7833.1	337.51	4.31

On account of the advanced stage of the lactation period of several cows the decrease in the production of milk and fat was more marked than would otherwise have been the case; the time of the year also introduced several disturbing factors: *first,* because the weather conditions were subject to great fluctuations and as the cows were outdoors most of the time they were more dependent upon the weather than in winter time, and *second,* because it was impossible to secure a uniform system of feeding throughout the experiment. The cows had to be changed repeatedly from a luxuriant oat pasture to an upland bluegrass

pasture and from this again to a lowland pasture, according to the supply of food or the weather conditions. The disturbing influence of the conditions mentioned is plainly shown by the milk records for the whole herd (including the cows on the experiment) during the different weeks the experiment was in progress. The total production of milk by all the cows in milk at this time was as follows:

Milk produced by whole herd, June 11—July 16.

	Week of experiment.	Total milk produced. Lbs.	No. of cows in milk.	Av. per head daily. Lbs.
June 11–18	1	4,828.1	29	23.7
June 18–25	2	5,265.5	29	25.9
June 26–July 2	3	4,470.8	29	22.0
July 2–9	4	3,997.2	28	20.3
July 9–16	5	4,228.4	28	21.6

We shall not here discuss the causes of the fluctuations shown in the preceding table since they are of minor importance in this connection, the main object being to study the influence of the method of after-milking upon the normal production of milk and fat from the cow.

The figures given in the last table but one permit of the following deductions:

1. *As to total production of the cows:* Considering first the regular milking, we note that there is only a slight difference in the production of milk and butter-fat for periods when after-milking was *not* practiced, and when it was. The total amount of milk produced by the ordinary method of milking, when the cows were not after-milked, was 7,566.1 pounds, and when they were after-milked, 7,492.9 pounds, a difference of less than one per cent. A similar difference occurs in the production of fat during the different periods. As the influence the advance of the lactation period was eliminated so far as possible in planning the experiment, we are justified in concluding that the thorough emptying of the udders of the cows during the days these were after-milked did not reduce the milk yields of the cows on days when only ordinary milking was practiced,

since we should otherwise have a smaller yield in the latter case than from regular milking alone in the former. This is especially plain when the records for Lot II are studied; in this case the cows were after-milked every other day, and milked only by the regular method on the intervening days. If taking out every drop of milk in the udder, e. g., today, by the method of after-milking, will tend to decrease the flow of milk tomorrow, the yield then obtained should be less than the regular milking of today; when we consider the totals for four weeks we find that such is not the case; on the other hand, there is evidence of a stimulating effect in the manipulation method, when the total results for Lot II and those for weeks 1 and 2 of the experiment are considered, while in case of the last two weeks there is a very slight deficit of 3.4 pounds on 1,084.5 pounds (.3 per cent.), for the days when only regular milking was practiced. Considering the yields from individual cows, we find an increase in seven instances and a decrease in nine instances; the total amounts in the former cases are, however, larger than in the latter. The differences in yields of milk and of fat as well as per cent. of fat in the udder on regular milking with or without subsequent after-milking, are small and may not signify much, but it is readily seen that the results cannot be interpreted as showing any depressing influence of the process of after-milking, on the production of milk and butter fat during periods following the after-milking.

Whatever be the interpretation of the results for regular milking days and after-milking days, the figures given in the table show that the yields obtained by the process of after-milking are essentially clear gain, so far as production alone is concerned. We shall later on discuss whether or not this increase is obtained at an extra cost.

2. *As to the amount of milk and butter fat in the after-milking:* On the average for all three lots of cows the yield of milk was increased by 338.8 pounds (4.5 per cent.) by the process of after-milking, and that of butter-fat by 28.52 pounds (9.2 per cent.). The increase in milk was 4.6 per cent. during weeks 1 and 2, and 4.5 per cent. during weeks 4 and 5; that of fat, 9.4 and 9.0 per cent., respectively.

The slightly lower gains obtained in the after-milking during the third and fourth weeks of experiment are in all probability explained by two facts: First, the herdsman did not go through the complete manipulations with all the cows during this time, as was the case during weeks 1 and 2, but only continued the manipulations so long as an appreciable stream of milk was obtained, so that in case of some cows which did not give down much milk on, e. g., the first manipulation, this was only made once and the other two manipulations three times, if necessary; he also made much lighter work of the manipulations during these weeks than in the beginning, since this had proved almost equally efficient in bringing down the last traces of milk in the udder. Second, the regular milkers milked somewhat cleaner during the latter part of the experiment, especially milkers I and II, having found out in a general way from the results obtained during the first two weeks that their work was not done as carefully as might be expected.

The average amount of milk obtained per day and per cow by after-milking was a little over one pound, and the amount of butter fat, .09 pound. The different cows gave quite different results in this respect, as will be seen from the tables on pages 23–25 of Bulletin No. 96, giving the yields of the cows in the different lots during each week of the experiment.

The percentage increase in the production of fat was, as a rule, quite constant for each cow, and varied from less than 5 per cent. to about 30 per cent., on the average; the lowest results were obtained with Maud (3.0 per cent.), Donation (4.0 per cent.), McGeoch (4.2 per cent.), Laura (4.2 per cent.), Dora (4.5 per cent.), Pauline (5.3 per cent.), Dixie (5.6 per cent.), and Ella (7.1 per cent.), and the highest results with Mary (30.2 per cent.), Elsie (16.9 per cent.), Bessie (14.3 per cent.), Muriel (14.2 per cent.), Dorine (13.3 per cent.), Belle (12.4 per cent.), and Lady (11.2 per cent.). The former cows include among their number three Shorthorns, two Holsteins, two Guernseys, and one Jersey; among the latter are one Shorthorn cow, four Guernseys, two Jerseys and one Red Poll. The breed has evidently nothing to do with the gain obtained in after-milking, neither does the conformation of the udder seem

to be much of a guide as to the amount of milk obtained in the after-milking. Since most of the cows tested by us were not milked perfectly clean by the regular milkers, the data obtained as to the exact amounts brought down by the manipulation method alone are hardly sufficient to permit of definite conclusions as to the relation of the shape or the quality of the udder to the amount of residual milk obtained.

THE DIFFERENCE IN MILKERS.

It becomes quite apparent on studying the data obtained on the experiment that the variations in the increase in milk and butter fat secured by the method of after-milking came as much from the character of the work of the milkers themselves as from the superior value of this method of milking. The cows giving the lowest gain were milked as follows: Three by milker No. II, and five by milker No. III; of those giving the highest gain, five were milked by No. I, two by No. II, and one by No. III. If the percentage increase in fat production and the absolute amounts of milk and of fat in the after-milking from the different cows be grouped according to the milker, we have the following statement:

Results obtained by different milkers on main experiment.

MILKER No.	NAME OF COW.	RESIDUAL		INCREASE OF FAT.
		Milk per day	Fat per day.	
		Lbs.	Lbs.	Per cent.
I	Mollie	.81	.06	8.1
	Joe	1.64	.08	10.8
	Chloe	1.42	.10	10.3
	Belle	1.71	.10	12.4
	Muriel	1.36	.15	14.2
	Mary	1.55	.14	30.2
	June	.60	.05	8.2
	Dorine	1.24	.15	13.3
	Average	1.29	.10	13.4
II	Maud	.58	.04	3.0
	Alma	1.48	.06	7.5
	Pauline	.65	.05	5.3
	McGeoch	.88	.06	4.2
	Lady	1.13	.10	11.2
	Gold	1.03	.10	7.6
	Rilma	1.09	.13	13.8
	Elsie	1.32	.12	16.9
	Average	1.02	.08	8.7
III	Ella	.79	.09	7.1
	Bessie	1.09	.10	14.3
	Laura	.41	.03	4.4
	[Dixie	.39	.03	5.6]
	Brownie	.80	.08	10.4
	Dora	.52	.05	4.5
	Donation	.55	.04	4.0
	Reba	1.03	.11	9.0
	Princess	.54	.05	8.7
	Average	.72	.07	7.8
	General average	1.05	.09	10.0

The figures given in this table represent average data for the different cows for a period of four weeks (week 3 of the experiment not being included therein); it is self-evident that much greater differences between the milkers would be likely to occur if data for short periods of a few milkings were considered. None of the attendants who milked the cows on this experiment would be considered poor milkers, except perhaps No. I, and still there is an extreme average difference of over one-half of a pound of residual milk and .03 of a pound of residual fat between them. The milkers were not changed during the experiment, but determinations of the amount of residual milk and fat in case of different cows have been made at different times during the past four months, when the same cows have been milked by different milkers. The data on this point available with cows in our University herd have been brought together in the following table, which shows at a glance the amount of

fat obtained in the after-milking with the same cows when milked by different milkers. The milkers designated as I–III in this table are the same as those of the same number in the preceding table.

Amount of fat in after-milk left by milkers I–V, per day.

Name of Cow.	I.	II.	III.	IV.	V.
	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.
1. Mollie	.06	.06	....	....	....
2. Muriel	.15	.14	....	....	....
3. Dorine	.15	.09	....	.21	....
4. Mary	.15	....	....	.08	....
5. Chloe	.10	....	....	.27	.05
6. Belle	.24, .10	....	....	....	.04
7. June	.11, .05	....	....	....	.03
8. Joe	.08	....	....	....	.02
9. Laura	....	.14	.03	....	....
10. Brownie	....	.10	.08	.07	....
11. Alma	....	.07	....	.14, .11	....
12. Donation	....	.03	....	.04	....
13. Kilma	....	.13	....	....	.05
14. Dora	....	....	.05	.08	....
15. Bessie	....	....	.10	.13	....
16. Princess	....	....	.05	.07	....
17. Ella	....	....	.09	.17	....
18. Dixie	....	....	.03	....	.02
Average	**.12**	**.10**	**.06**	**.13**	**.04**

Differences greater than two-tenths of a pound of fat are found three times in this table and differences of one-tenth of a pound occur often in case of single cows. The greatest difference in the averages for the individual milkers is .09, or nearly one-tenth of a pound. A difference in the daily production of fat of one-tenth of a pound would mean one pound for every ten cows; at 25 cents a pound for butter fat the best milker would, therefore, increase the returns from the dairy by 25 cents every day per ten cows, that is, he would be worth at least $7.50 a month more to the owner of the herd than the milker leaving most milk and butter fat in the udder.

Comparisons of the work of the same milkers.—Not only do different milkers leave different amounts of milk in the udders of the same cows, but the same milker does his work more or less carefully at different times, according to how crowded with other work he is, or thinks he is, according to how much he is interested in the work of milking at the time, or whether he feels that he is watched or not. A number of determinations of residual fat with the same cows milked by the same milker

are at hand which will illustrate the correctness of the statement made. Milker No. II left .09 lb. of residual fat, on the average for 8 cows, June 10–18; .07 lb., July 2–9; and .11 lb., August 10–19 (average for 5 cows).

B. EXPERIMENTS CONDUCTED AT OTHER DAIRY FARMS.

In order to secure further data as to the value of the manipulation method of milking with cows kept under different conditions, and as to the character of the milking done on different dairy farms, it was decided to extend the investigation to a number of Wisconsin dairy farms of different kinds, and to determine the amount of after-milking obtained from different cows as well as the percentage average increase of fat produced by the cows. Ordinarily, about ten cows were tested in each herd, the cows being after-milked by Mr. Harris immediately after the regular milking was finished or at most within a minute or two thereafter. Before the various manipulations of the udder wer made and the residual milk drawn, the cows were milked clean by Mr. Harris by the ordinary method of milking if the milking had not been done thoroughly by the regular milker. A note was always made (during the later trials, at least) when some milk was obtained by him by the ordinary method of milking, so that we are able to tell whether the milking was clean in case of any particular milker.

The detailed accounts of the tests conducted at twelve different dairy farms, with descriptions of the latter, are given in Bulletin No. 96 of this Station.

The main results of the tests have been summarized in the following table, which will show at a glance the average production of the cows tested in the different herds, the amounts of milk and butter fat obtained by the manipulation method, the percentage gain in fat, range in gain, etc.

Summary of results of tests of cows in herds Nos. 1-12.

No. of Herd.	No. of cows tested.	Av. Yield per Day.		After-Milking.		Av. Gain.		Range in gain of fat for individual cows.	Resid. fat over 10 pr.ct.	Residual Milk Less than	
		Milk.	Fat.	Milk.	Fat.	Milk.	Fat.			.5 lb.	1 lb.
		Lbs.	Lbs.	Lbs.	Lbs.	Pr ct.	Pr ct.	Per cent	No of cows.	No. of cows.	No of cows
1	11	23.1	1.09	.75	.09	3.2	8.1	2.2-22 3	3	3	8
2	10	49.0	1.66	1.79	.14	3.7	8.3	2.7-23.6	3	0	4
3	12	31 2	1.58	.55	.07	1.8	4 4	1.5-11.3	2	5	11
4	8	25 5	1.10	.76	.08	3.0	7.5	2.2-15 9	3	2	5
5	8	18.6	.83	61	.07	3.2	7.9	3 8-12.5	4	2	8
6	15	28.4	.80	1.87	.16	10.2	20.1	4.4-37 5	12	2	5
7	8	13.5	.59	1.25	.13	9.3	22 4	9.6-58 5	7	1	3
8	10	26 8	.85	1.08	.08	4.0	9.2	2.8-19 7	6	0	5
9	6	12.0	.54	.59	.06	4.9	11 5	4 3-21.3	4	3	5
10	10	11.7	.61	.81	.12	6.9	19.1	3.9-71 9	5	4	7
11	11	16.0	.62	1.02	.10	6.4	16 2	4.4-72 1	7	3	8
12	8	20.8	.92	1.68	.18	8 1	19 7	5 5-57 2	6	0	4
Univ. herd	25	22.3	.93	1.01	.09	4.5	9.2	3.0-30 2	11	2	12
Total & av.	142	......	......	1.08	.10	5.3	12.6	1.5-72.1	77	27	85

C. DISCUSSION OF RESULTS.

This investigation has up to the present time furnished data for 142 different cows as to the amount of milk and butter fat obtained by combined clean milking and use of the so-called manipulation method of milking. The majority of the tests made with these cows have been for the brief period of three milkings, only twenty-four of the cows in the University herd having been kept on the test for a longer time, viz., for five weeks, and a few cows among these for nearly four months. Judging from the results obtained during this longer experimental period, we feel justified in concluding, however, that the results of tests conducted for two or three successive milkings give a fair indication of the direct, every-day losses in dairy herds due to careless or not sufficiently careful milking and that the results of the brief tests are at all events not appreciably too high, owing to the conditions under which the tests were conducted.*

The average results of the determinations of the amounts of milk and butter fat obtained in the after-milk in case of the 142 cows have been compiled, and a summary of the compilation is presented below.

*See Bulletin No. 96, pp. 31-32.

Amounts of milk and butter fat in residual milk, per day.

Summary for 142 cows.

Residual Milk.	No. of cases.	Per cent. of total No.	Residual fat.	No. of cases.	Per cent. of total No.
Lbs.			Lbs.		
.20— .25	9	6.3	.02— .05	44	31.0
.26— .50	28	19.8	.06— .10	55	38 8
.51— .75	30	21.1	.11— .15	21	14.8
.76—1.00	19	13 4	.16— .20	6	4 2
1 01—1.25	21	14.8	.21— .25	8	5.6
1.26—1.50	12	8 5	.26— .30	2	1.4
1.51—1 75	7	4 7	.31— .35	3	2.1
1.76—2 00	2	1.4	.36— .40	1	.7
2.01—2.50	1	.7	.41— .50	1	.7
2.51—3.00	5	3.5	.51— .64	1	.7
3.01—3 50	3	2 1			
3 51—4.00	2	1.4			
4 01—4 50	2	1.4			
4.51—5.50	1	.7			
Total........	142	100 0	....	142	100 0

The largest amount of milk per day obtained in the after-milk from any one cow was 5.5 lbs., and of fat .64 lb., the smallest amount being .20 and .02 lbs. of milk and fat, respectively. The figures in the table show that about a quarter of the cows gave less than one-half pound of residual milk, about one-third gave between one-half and 1 pound, and nearly another third gave between 1 and 2 lbs. Ten per cent. of the cows gave more than 2 lbs. of milk per day in the after-milking. The average amount of residual milk for the 142 cows was 1.08 lbs. per head per day.

Considering the amounts of residual fat per day obtained we find that a little over two-thirds of the cows gave less than one-tenth of a pound of butter fat in the after-milking, thirty per cent. giving more than this amount. The extremes found were .02 and .64 lbs., and the average for all cows one-tenth of a pound per head per day.

If due care is taken in milking the cows, less than half a pound of milk per day extra will, as a rule, be obtained by the use of the manipulation method with good dairy cows that are in full flow of milk, and with perhaps a majority of such cows this amount will come nearer one-quarter of a pound than half a pound; but in every herd so far examined we have found some cows that would be considered excellent dairy animals, which have given toward one pound of milk extra per day, or

more, representing at least one-tenth of a pound of butter fat. The lowest maximum amounts of milk and butter fat found in the after-milking in any of the herds tested by the writer up to the present time were .8 lb. milk and .09 lb. fat, and it is evident, that it is only under exceptional conditions and with very careful milking that some cows in a herd will give as small quantities of milk and butter fat as this in the after-milking.

The figures given for the ordinary quantities of milk and fat obtained in case of good dairy cows, naturally presupposes clean milking. Where the cows are not milked clean, the figures are higher and will come as shown in the data for various herds examined. The average quantities of milk and fat obtained in the after-milking in case of these herds were 1 lb. and .1 lb., of milk and fat, respectively, per cow and per day; from what has just been said it follows that perhaps the greater portion of these amounts would have gone into the milk drawn by the ordinary method of milking, had this been carefully done in all cases.

QUALITY OF RESIDUAL MILK.

It has been stated that the fat content found in the residual milking is ordinarily from two to three times as high as that of the regular milking. The following table shows the data obtained on this point with cows at our University farm as well as with those in outside herds where tests were conducted.

Average fat content in milk.

	Av. for No. of cows.	Regular. milking.	Residual milking.	Ratio.
		Per cent.	Per cent.	1:
University herd	25	4.12	8.42	2 0
Herd No. 1	11	4 71	11.83	2.5
2	10	3 38	7.71	2.3
3	12	5 03	12.68	2.5
4	8	4.31	10.81	2.5
5	8	4 49	10.93	2.4
6	15	4.34	8.59	2.0
7	8	4.36	10 50	2.4
8	10	3.12	7.26	2 3
9	6	4.46	10 42	2.3
10	10	5 19	14.41	2.8
11	11	3 87	9 91	2.6
12	8	4 40	10.71	2.4
Average per cent. of fat	....	4.29	10.32	2.4

The average fat content of the milk from the thirteen herds examined was 4.29 per cent. and that of the residual milk 10.32 per cent. The latter figure is 2.4 times as large as the former. The fat content of the mixed herd milk ranged from 3.12 to 5.19 per cent. and that of the after-milk from 7.26 to 14.41 per cent. The lowest figures for milk and after-milk were obtained in the same herds, and this was also the case with the highest figures; as a rule, the fat content of the residual milk follows that of the regular milking: it is generally high when this is high, and low when this is low. The highest per cent. of fat so far found in any sample of after-milk is 23.0 per cent. (in case of a cow in herd No. 10; the yield of after-milk at this milking was .85 lb.; the regular milking of the cow weighed 11.0 lbs. and tested 7.40 per cent.).

IMPROVEMENT IN QUALITY OF MILK BY ADDITION OF AFTER-MILKING.

The subject of clean milking is of importance to the dairymen and cow owners not only on account of the increased yields of milk and of butter fat which thereby are obtained, but since the strippings are always the richest portion of the milking, the average fat content of the whole milking from a cow or from a herd is increased by adding these to the mess of milk. This is of especial importance where the mixed herd milk is apt to come below a standard set, e. g., 3 or 3½ per cent. By thorough milking—which means not only clean milking in the ordinary sense, but this followed up by manipulation of the udder—the average fat content of the milk from a cow or a herd may be increased from one- to six-tenths of one per cent., according to the thoroughness with which the work of milking was previously done. In the experiments conducted with our University herd as well as on outside farms the results obtained have always been calculated with the view of ascertaining the improvement in the quality of the milk brought about by the addition of the after-milking to the mess of milk obtained by the ordinary method of milking. The average results arranged for the different herds are shown in the following table.

Improvement in quality of milk caused by addition of after-milking.

	Per Cent. of Fat in Mixed Milk from Whole Herd.		Improvement in fat content, per cent.
	Regular milking.	Residual milk added.	
University herd	4.12	4.31	.19
Herd No. 1	4.71	4.92	.21
2	3.38	3.53	.15
3	5.08	5.20	.12
4	4.31	4.49	.18
5	4.49	4.69	.20
6	4.34	4.73	.39
7	4.36	4.88	.52
8	3.12	3.32	.20
9	4.46	4.74	.28
10	5.19	5.78	.59
11	3.87	4.24	.37
12	4.40	4.88	.48
	4.29	**4.59**	**.30**

DISCUSSION OF THE MANIPULATION METHOD OF MILKING.

The results presented show that an appreciable increase in the immediate production of milk and butter fat from dairy cows can ordinarily be obtained by manipulation of the udder. There are several questions which should be carefully considered and answered, however, before the merits of this method of milking can be deemed established. We must know:

First, How do the cows take to the method?

Second, Do the increased yields continue indefinitely, or do the cows gradually adjust themselves to the method so that after a while no gain in production is noticeable?

Third, What, if any, is the extra expense of this method of milking?

Fourth, Can it be readily learnt and practiced by old or young milkers, and

Fifth, What are the advantages of the method, if any, aside from the gain in production?

We shall briefly consider these questions in their order. It is believed that the results presented in the preceding and the practical experience and testimony now at hand will warrant the following statements.

1. *As to the effect on the cows.*—Of the cows on which the manipulation method has been tested so far, numbering over

150 in all, less than a dozen have in any way objected to the manipulations. The part of the method which these few cows did not like was generally the third manipulation. These cows or heifers were as a rule of a very nervous temperament, and more or less inclined to give trouble also by the ordinary method of milking. The large majority of cows, on the other hand, seem to like the method; they stand chewing their cud when after-milked, and are apparently at as perfect peace with the world and their immediate surroundings while the process of after-milking is going on, as when milked in the ordinary way.

2. *As to the persistency of the gain in production.*—If the results obtained with the different herds examined as regards the yield of milk and fat from individual cows on the first and the third milkings of the tests, and the average per cent. of fat for these milkings in the milk from all the cows tested are compared, we find that in 22 cases there was a higher yield of milk and in 10 cases a higher yield of fat on milking I than on milking III; in 59 cases a lower yield of milk, and in 56 cases a lower yield of fat, while in two and five cases the same yields of milk and of fat, respectively, were obtained on both milkings. These figures show with considerable certainty that a milking immediately succeeding one where the manipulation method has been practiced, is apt to be lower in milk and especially lower in fat than the corresponding milking following an ordinary milking, and in the case of eight out of nine herds the average fat content of the milk was lower at the former milking than at the latter.

This is perhaps what one might expect, that when the udder of a cow is completely emptied of milk, as occurs by practicing the manipulation method, less than normal amounts will be obtained at the next milking. When a longer period is considered, however, no such depressing influence is apparent; on the contrary, on the experiment with cows in our University herd previously reported, we found a somewhat increased yield on regular-milking days, compared with that of regular milkings alone on days when after-milking was practiced. If we are justified in accepting this evidence as conclusive, it

follows that the milk glands of the cows after a short while are able to adjust themselves to the thorough emptying of the udders, and are stimulated thereby to increased production. As a matter of fact, this was also found to be the case with the cows on the experiment, which showed a decrease in production on the third milking over the first one, but an increase again on later corresponding milkings.

The gain obtained by after-milking (or rather, by perfectly clean milking plus after-milking) seems to be fairly constant for each cow, when absolute quantities are considered. Since the production of a cow as a rule gradually decreases during the latter part of the lactation period, we should expect to see the percentage gain increase as the cow becomes an old miker. The experiment was not continued sufficiently long, however, to establish any such percentage gain; larger differences were found in the results obtained with different milkers, or even the same milker at different periods, than with the same cows at different stages of their periods of lactation (see pp. 88–89).

In order to secure some direct evidence on this point, an experiment with two cows in the University herd has been conducted for the past twenty weeks. The cows have been after-milked regularly every milking by milker No. IV, after having first been milked clean by him by the ordinary method of milking; the two lots of milk were kept separately, weighed and sampled, and composite samples for a week at a time tested by the Babcock test. The data presented in the following table show the weekly yields per cow of both regular and residual milk and butter fat, as well as the percentage increase in the latter obtained through the process of after-milking.

FIG. 15a.—Reba's udder.

FIG. 15b.—Mary's udder.

FIG. 16.—Donations udder.

FIG. 17.—Joe's udder.

FIG. 18.—McGeoch's udder.

Results of after-milking tests with Reba and Mary, weekly yields.

	Reba.					Mary.				
	Milk.		Fat.		Gain in fat.	Milk.		Fat.		Gain in fat.
	Reg.	Res.	Reg.	Res.		Reg.	Res.	Reg.	Res.	
	Lbs.	Lbs.	Lbs.	Lbs.	Per cent	Lbs.	Lbs.	Lbs.	Lbs.	Per cent.
First week on milking experiment:										
June 10-18	......	......	......	......	....	76.3	13.05	3.24	1.12	34.6
June 18-25	198.2	6.30	9.36	.80	8.5	......	......	....	......	......
July 16-23	129.5	14.75	5.83	1.47	25.2	80.8	5.53	3.72	.51	13.7
23-30	121.2	18.25	5.09	1.74	34.2	77.5	5.65	3.57	.55	15.4
30-Aug. 6	106.6	22.85	4.16	2.29	55.0	72.6	5.85	3.30	.61	18.5
Aug. 6-13	128.2	12.60	6.41	1.56	24.3	68.4	5.90	2.91	.58	19.9
13-19	145.5	15.80	6.98	1.93	27.7	67.6	5.75	3.11	.60	19.3
19-26	137.8	11.35	6.89	1.33	19.3	69.2	5.35	3.25	.54	16.6
26-Sept. 3	130.9	6.70	6.26	.67	10.7	68.0	4.00	2.99	.38	12.7
Sept. 3-10	117.1	8.60	5.74	.80	13.9	66.0	4.80	2.97	.46	15.5
10-17	108.9	9.20	5.39	.85	15.8	68.2	4.55	3.00	.34	11.3
17-24	100.4	7.25	4.97	.80	16.1	59.1	3.15	2.84	.30	7.0
24-30	82.9	8.80	4.23	.79	18.7	57.2	3.45	2.77	.36	13.0
Oct. 1-7	71.1	10.55	3.80	1.00	26.3	51.1	3.40	2.43	.35	14.4
8-15	7.18	10.25	3.74	.95	25.4	54.3	3.85	2.72	.47	17.3
15-22	69.5	7.70	3.27	.62	19.0	57.4	3.45	2.76	.31	11.2
22-29	45.5	8.90	2.35	.77	32.8	45.9	4.35	2.30	.43	18.7
29-Nov 5	47.3	6.85	2.51	.59	23.5	43.3	4.52	2.08	.48	23.1
Nov. 5-12	59.0	7.4	3.10	.65	22.0	41.0	3.9	2.38	.41	17.2
12-19	42.0	6.85	2.48	.65	26.2	36.8	2.8	2.17	.31	14.3
19-26	37.3	3.75	2.09	.32	15.3	35.1	3.6	2.00	.37	18.5
26-Dec. 3	35.4	3.00	2.09	.32	15.3	41.0	2.65	2.21	.27	12.2

Reba calved February 25, 1902, and was due to calve in 7 months at the beginning of this experiment, while Mary calved January 24, 1902, and was about 8 months from next calving (see p. 81). During the milking experiment, June 10 to July 16, Reba was milked by milker III, and Mary by milker I (see p. 81). The cows were treated as nearly alike as possible during the past twenty weeks; they were milked every time by the same man, at the same hours, and in the same order, with only absolutely necessary changes in their food rations. Mary was fairly regular; Reba, on the other hand, varied greatly in the amounts of milk given down by the manipulation, especially during July and August, often holding up a couple of pounds of milk at a milking, which could only be obtained by the means of the manipulation method. As several cows in the herd who had been on the milking experiment showed similar tendencies to hold up their milk at this time, it was believed that the previous experiment, directly or indirectly, caused the difficulty; that it at least was

the after-effect of too much stripping during the experiment by two of the milkers. There is no real foundation for this belief, however, and no explanation of the variations can be offered except that the cows were old milkers, which are known often to give difficulties in this direction.

3. *The cost of the manipulation method.*—The cost of the manipulation method is mainly dependent on the length of time required to do the milking by this method, since the food question, if affected at all by the method of milking, is of minor importance on account of the high value of the manufactured products. The time required to go through the various manipulations by the Hegelund method will of course depend on the practice which the milker has obtained and whether he is a rapid milker or not; at first the manipulations will take at least 4 or 5 minutes, but when the milker has become more familiar with them they will not require more than a couple of minutes. There is considerable difference in different cows as to the efficiency of the manipulations in bringing down the last portions of the milk. Some cows give down nearly all the milk remaining in the udder on the first manpulation and only a little on the other two manipulations, while others continue giving down a little milk throughout the process of after-milking. With cows of the former kind it is not necessary to go through all three parts of manipulations II and III, and the time of after-milking such cows may therefore be somewhat shortened.

The time required for after-milking the cows in our University herd was observed in a large number of cases (8 to 14 times per cow), and on the average it was found to take 2.6 minutes to after-milk a cow toward the close of the experiment. One man can readily after-milk 20 cows an hour if there are no extra weighings, sampling and recording of weights to be done. We pay at this Station 15 cents an hour for milking. This may be considered a rather high price under present conditions in the northwestern states. The after-milking of 20 cows would take a man about 2 hours a day and would therefore cost 30 cents. We have seen that we obtain on the average an immediate increase of about 1 pound of

milk and one-tenth of a pound of butter fat per cow by the process of after-milking, or from 20 cows, two pounds of butter fat. If butter fat is worth 25 cents a pound (an average figure), the value of the increased yield would be 50 cents, that is, there would be a gain of 20 cents a day per 20 cows, or about $60.00 a year, as the direct and immediate gain from practicing the manipulation method. If the value of the fat be less than 25 cents a pound, the gain would be correspondingly reduced, but the account would at all events be apt to come out on the credit side, even if only immediate results are considered.

In the milking experiments conducted so far at our Experiment Station, we have divided the work of milking into two parts, the ordinary milking and the after-milking, and these have been done either by different or by the same milkers. This plan was adopted as the one most likely to give direct evidence as to the value of the manipulation method; it can also be followed to advantage on the dairy farm in this manner that one or more good, reliable milkers who are especially interested in the cows, do the after-milking for all the cows. Some dairymen believe that such a system of milking has a bad influence on the cows, that it would tend to make them hold up their milk and leave more and more to be drawn by the process of after-milking. This belief is not, however, borne out by the experience of many observing dairymen. It is not known whether it is the regular practice of any dairy farm to have the cows stripped by one or more men, after the regular milkers are through, but this method of milking is generally practiced by farmers in the districts of France where the famous Roquefort cheese is manufactured; the ewes kept for the manufacture of this cheese are always stripped by a special milker after the regular milkers have drawn what milk they could get from them.*

In a recent letter to the writer, the Danish State Dairy Instructor, B. Böggild, gives the following information on this point: "I have never heard it mentioned here in Denmark that the Hegelund method might cause the cows to hold up

*Oesterr. Molkerei-Ztg., 1902, p. 167.

their milk. But, of course, the manipulations take some time. On the whole, the work of Dr. Hegelund has been very satisfactory. The method is, however, doubtless of the greatest importance to the many small cow owners who are looking after *personal* interests."

It is not necessary, however, to follow the plan mentioned in order to secure a maximum yield of milk from the cows. The method that seems preferable for several reasons is for all milkers to learn the manipulations and to use these as soon as a full flow of milk has ceased by the ordinary milking. There is no need of stripping the cows at all when the after-milking thus follows directly after the ordinary milking, for the milk left in the udder by the regular method will be readily brought down by the manipulations and the time it takes to strip the cows would ordinarily suffice for the manipulations. It is safe to say that the process of after-milking conducted in this way will not take more than a minute longer than ordinary clean milking. The extra expense of the manipulation method under these conditions is reduced to a figure that is hardly worth considering.

4. *Learning the manipulation method.*—The method is easily learnt by any person who knows how to milk. It takes a little time before some degree of expertness can be reached, but an intelligent and observing milker will not be apt to begrudge the time spent in becoming familiar with the different manipulations since the results obtained will prove stimulating and will furnish an incentive to good work. The practical courses for milkers which Dr. Hegelund has been conducting during the past year in Denmark with government aid, have been of only six days' duration; it is believed that intelligent milkers will become thoroughly familiar with the various parts of the method in this time and attain considerable proficiency with it. Persons learning the manipulations are as a rule apt to make too hard work of it; the manipulations should be done lightly so as to cause no irritation to the cow or waste of energy on part of the milker. It requires but very light manipulations to bring down the residual milk in the udder nearly as completely as is possible by doing a

hard task of the manipulations. (For a description of the manipulations, see p. 77.)

5. *Some advantages of the manipulation method.*—The only advantage of the manipulation method which has been considered to any extent in the preceding discussion is that of the immediate increase in the production of milk and butter fat which it gives, over and above the ordinary method of milking, especially as this seems to be ordinarily conducted. It is a question, however, whether the other advantages of the method which will be considered below, are not even more important than the direct gain in milk and butter fat.

a. *Effect on the persistency of the milking habit.*—We have had occasion to refer to one other point in favor of the method, the tendency to better maintaining a maximum flow of milk throughout the period of lactation, which the thorough emptying of the udder by the manipulation method may be found to possess. It is well known that there is no more certain method of drying off a cow than by leaving considerable milk in her udder for a number of milkings. The milk glands like all other organs of the animal body are developed by being worked. If the entire secretion of milk is not removed and the *alveoli* not thoroughly emptied, they are not stimulated into renewed activity and after a while more and more of them will be unable to grow and manufacture milk-producing materials. The complete emptying of all the contents of the alveoli of the milk glands is the best possible stimulus which these can be given. This holds good with special force in case of heifers coming in. The milk glands of these young animals are still in the process of development; by frequent and thorough milking, half a dozen times a day, if possible, the milk glands are stimulated to great activity and will reach the highest development of which they are capable. Single cases are on record showing that in some instances it has been possible to nearly double the production of young heifers in the course of a couple of weeks by this method of procedure, even when the frequent milking by the manipulation method was not commenced until they had apparently reached their maximum yields.

b, *Effect on the offspring.*—Another advantage of this method of milking lies in the effect on the offspring of developing a high productive capacity in the cow. According to a well-recognized law of heredity, "like begets like;" a dairy cow whose milk-producing capacity has been developed to its greatest perfection will be likely to transmit this quality to her offspring, and these will be large and persistent milkers and valuable dairy cows according to the extent to which the faculties of the dam for transforming plant materials into milk and butter fat have been developed.

c, *Influence on the quality of the milk produced.*—We have seen that the quality of the milk from a cow and from a herd will be materially improved by the addition of the after-milking to the regular mess of milk, viz., by about three-tenths of one per cent., on the average. This is of course of value to all milk producers who desire a good quality of milk, but as previously suggested, it is of special importance where the milk is sold for direct consumption and must come up to a certain standard of fat content. We have been told that the only way in which mixed herd milk testing below the state standard can be sold is to add some cows to the herd that produce milk of a high fat content or sell off some of those giving milk of a low fat content. The results given in the preceding show, however, that the dairy farmer has it in his power to increase the per cent. of fat in the milk produced by his cows by a simpler and more inexpensive method, viz., through extra care in milking, by taking pains to secure all the milk in the udder of the cow at the time of the milking.

d, *Prevention of udder diseases.*—Careful and exhaustive milking is also an important factor in preventing diseases of the udder. The losses which the dairy farmer sustains through defective udders or a diseased condition of these are larger than many suspect. Inflammation of the udder is by no means an unusual occurrence on the dairy farm. It generally comes after calving, at a time when the flow of milk is nearly at its highest, or when the cow is being dried off. While it usually yields to treatment after a short time, it often results

in leaving behind uneven quarters and one or more teats that do not give milk; if the inflammation did not spread to the whole milk gland, this will still give milk when the quarter has recovered, but the yield will be smaller than usual and the production of the cow for the year thereby reduced. This reduction may amount to a large percentage of the total yield of the cow. The variations in the yield of milk from a cow from year to year are doubtless often to be traced to this cause.

When inflammation of the udder occurs, as shown by a hard, caked condition of one or more quarters and an abnormal secretion of milk, this being filled with fine cheesy matter, the best preventive is to empty the milk of the diseased part thoroughly, at least every hour. The udder is thus completely and in as short time as possible freed from the bacteria which give rise to the inflammation, and is generally restored to a healthy condition and to normal milk secretion within a few days. The milker who watches his cows carefully and takes pains to remove at once milk of abnormal appearance from the udder by frequent and exhaustive milking (including manipulations) may stop inflammation while it is still in its early stages, thus saving the owner considerable losses of milk and possibly saving a cow for the dairy. Milk of the character mentioned is of course not fit for direct consumption and should be thrown away outside of the stable, or sterilized and fed to young stock. It should not be milked on to the stable floor or into the manure gutter so as not to spread contagion, nor added to the milk from the healthy cows, as it may make the whole mess unfit for the manufacture of dairy products.

e, *Cows holding up their milk.*—Cows sometimes do not let down all of their milk during a milking, through a congestion of blood in the veins or the arteries of the udder, which closes the sphincter muscles at the branching points of the various milk ducts in the udder. The investigations here reported have repeatedly furnished proof that a cow can not, as a rule, continue to hold up her milk after a few manipulations of the udder have been practiced. When a cow does not give her usual mess of milk and there is no reason to suspect that

she is sick, she is very likely holding up a portion of her milk, and in such a case it is especially important to finish up the milking by the manipulation method. This will generally give the owner about the usual amount of milk from the cow and will leave the milk-secreting glands of the udder in proper condition for the manufacture of milk for the next milking.

f, *Influence on the milker.*—We notice how the work of the milker becomes more and more important in view of these considerations, and as the importance of the work is more appreciated, the person performing it will be more highly respected and will himself look upon his work with selfreliance and watchful interest. He will know that each cow will only give down all the milk she has if he does his work conscientiously, and that unless he does it well, the result will not only be a direct immediate loss of milk, both as regards quantity and quality, but an indirect one, which may make itself felt throughout the whole period of lactation and permanently decrease the value of the cow as a dairy animal. It is one of the credit marks which belong to the manipulation method of milking that it has brought the importance of the work of the milker prominently into the foreground.

In many parts of this country, as well as abroad, it is often difficult to get good milkers, and the objection will no doubt be raised against giving more time and attention to the work of milking than is now the case, that it is hard enough to get the work done as it is. If the conclusions drawn from this investigation are correct, however, the milk yield of our cows can be permanently increased by about 12 per cent. by a system of exhaustive milking, i. e., eight cows can be made to yield as much as nine do now. This would not require any more time for the work of milking than is now given to it, if the milker practices the manipulations as soon as a full flow of milk has ceased, and would mean a saving of feed and an investment of a smaller capital.

SUMMARY.

The following is a summary of the investigation reported in the preceding pages:

1. The milking experiments conducted by the writer were made partly with cows in our University herd, partly with cows in twelve different Wisconsin dairy herds. The aim in all cases was to ascertain the gain in the production of milk and butter fat obtained by a system of manipulations of the udder after the regular milking was finished (Hegelund method); where the regular milker did not milk clean, the gain obtained by clean milking together with manipulation of the udder was ascertained. The plan of the experiments was therefore such as to show the character of the work done by the different milkers.

2. In our University herd the average daily production of milk from 24 cows was increased by 4.5 per cent. by means of the manipulation method and the production of fat was increased by 9.2 per cent. (range 3.0–30.2 per cent. for individual cows), as the result of a milking experiment continued for four weeks; the average gain in milk being 1 pound and in fat .09 pound per head per day.

3. A similar average increase in production was obtained for the twelve dairy herds tested, viz., a gain of 1.08 pounds in the daily production of milk per cow and .1 pound of fat. The results obtained in this investigation, extending over a period of four months, with cows in all stages of lactation, indicate that this gain is maintained through the whole period of lactation. An increase in the daily production of butter fat per cow, of one tenth of a pound, for the million cows in the State would mean an annual gain of 30,000,000 pounds of butter fat if the cows give milk 300 days in the year; the value of this increase to the dairy industry of the State would be about $6,000,000, on basis of a valuation of 20 cents a pound for butter fat, a figure considerably below average Elgin prices.

4. The largest amount of milk obtained from a cow by the manipulation method, after the regular milking was done, was 5.5 pounds per day and the lowest, .20 pound. The corresponding figures for fat production was .64 and .02 pound. The former figure is considerably above the average total daily production of cows in this or other States.

5. The greater portion of the gains obtained came through lack of care on part of the regular milker as the cows were not milked perfectly clean. But even in herds where the milkers did their work well, there were always one or more cows which gave an increase of nearly a pound of milk and one tenth of a pound of butter fat by the manipulation method.

6. The milk obtained by the manipulation method is similar in composition to that of "strippings"; on the average for all herds it contained 10.32 per cent. fat and was found to be about two and one-half times richer than the ordinary milk. The highest per cent. of fat found in the after-milking from any one cow was 23.0 per cent. and from any herd, 14.41 per cent.

7. The difference in the work done by different milkers is brought out strongly by the results of the work done. In several cases one milker did his work so much better than the others in the same herd as to be worth nearly $10.00 a month more to the owner, on account of the larger yields of milk and fat which he obtained from the cows milked by him.

8. The results obtained in this investigation suggest that a thorough system of milking is a foundation requirement in successful dairying. For, aside from directly increasing the production of milk and fat from the cows, exhaustive milking will be likely to maintain a maximum flow of milk throughout the lactation period and to permanently develop the dairy qualities of both the dam and her offspring.

OFFICIAL TESTS OF DAIRY COWS, 1901-1902.

F. W. WOLL.

The work of determining the production of milk and butter fat by pure-bred dairy cows for a limited number of days, which this Station has been engaged in since 1894, was continued during the past year in a similar manner as heretofore. The majority of the tests were conducted in co-operation with the Holstein-Friesian Association of America, as has been the case in earlier years, but Guernsey, Jersey and Red-Polled breeders have also during the past year availed themselves of the services of the Station to establish the production of cows owned by them. The tests of the Red Polled cows conducted were made at the request of the Union Stock Yard and Transit Co. of Chicago, to ascertain the production of butter fat by cows entered in the "Farmers' Cow Contest," three or four tests of seven days each having been made in case of each cow entered in this contest. The number of separate tests conducted between July 1st, 1901, and October 1st, 1902, were as follows: for Holstein breeders 46 tests, for Guernsey breeders 14 tests, for Red Polled breeders 7 tests, and for one Jersey breeder, 8 tests.

The tests ranged in length from one day in case of the Guernsey tests and seven days for the Jersey, Red Polled and most of the Holstein tests, to thirty days in case of some of the Holstein tests. 196 different cows were tested in all, belonging to nineteen different breeders.

A. OFFICIAL TESTS OF HOLSTEIN COWS.

One hundred ninety two tests of individual cows were made during the year, of which number 14 cows were tested more

than once. Fifty-five of the individual tests were with cows over 5 years old, 29 with cows between 4 and 5 years old, 44 with cows between 3 and 4 years old, and 64 with cows under 3 years old. In addition to these seven-day tests a large number of cows were tested for a period of three days or less, which tests are not reported on in the following tables.

The names and addresses of the different Holstein breeders whose cows were tested during the interval mentioned are given below, the numbers in each case referring to those given in the column headed, "Cow No.," in the sub-joined tables.

(1) I. L. Curtis, Poynette, Wis., Nos. 7, 79, 80, 82, 125, 126 and 127.

(2) W. Everson & Son, Lake Mills, Wis., Nos. 70, 71, 158, 159 and 176.

(3) E. J. Fargo, Lake Mills, Nos. 20, 24 and 92.

(4) F. B. Fargo, Lake Mills, Wis., Nos. 4, 5, 6, 8, 9, 19, 21, 22, 23, 27, 28, 29, 30, 31, 41, 42, 50, 55, 56, 57, 65, 73, 74,, 78, 85, 86, 89, 90, 96, 97, 110, 111, 116, 132, 143, 145, 146, 147, 150, 151, 152 and 174.

(5) Malcolm H. Gardner, Darien, Wis., Nos. 13, 14, 45, 60, 88, 128, 129, 134, 135, 138, 148, 149 and 166.

(6) W. R. Gates, Fort Atkinson, Wis., Nos. 17, 18, 131, 156 and 157.

(7) Gillett & Son, Rosendale, Wis., Nos. 15, 16, 25, 58, 59, 83, 84, 93, 139, 140, 141 and 142.

(8) S. B. Jones and Son, Watertown, Wis., Nos. 33, 34, 35, 48, 67, 68, 76, 103, 104, 114, 115, 144, 154 and 173.

(9) W. H. Jones, Watertown, Wis., Nos. 2, 3, 43, 44, 46, 64, 95, 112, 123, 124, 169, 170 and 171.

(10) A. N. McGeoch, Aztalan, Wis., Nos. 10, 11, 26, 32, 37, 38, 39, 49, 51, 52, 53, 54, 61, 62, 63, 66, 72, 77, 91, 94, 101, 102, 106, 107, 117, 130, 136, 137, 153, 160, 161, 162, 163, 164, 165 and 175.

(11) Moore & Kimball, Lake Geneva, Wis., Nos. 12 and 81.

(12) E. C. Petrie, Bowers, Wis., Nos. 47, 75 and 172.

(13) E. E. Randall, Watertown, Wis., Nos. 1, 36, 40, 69, 98, 99, 100, 105, 108, 109, 113, 118, 119, 120, 121, 122, 155, 167 and 168.

(14) C. A. Schroeder, West Bend, Wis., Nos. 87 and 133.

In conducting these tests the Station employed seven young men, graduates of the Short Course in Agriculture in the University of Wisconsin or of the Dairy Course in this College. Mr. Roscoe H. Shaw, late acting Chemist of this Station, conducted tests of cows in one herd.

The names of our Supervisors of Dairy Tests during the past year, with the cows tested by each of them, are:

J. D. Clarke, Milton, Wis., tested cows Nos. 2, 20, 24, 33, 34, 35, 36, 40, 43, 44, 46, 48, 64, 67, 68, 76, 92, 95, 103, 104, 105, 108, 109, 112, 114, 115, 123, 144, 154, 169, 170, 171, 173.

P. A. Dukleth, Big Bend, Wis., tested cows Nos. 36, 69, 100, 105, 155.

Roy T. Harris, Warrens, Wis., tested cows Nos. 7, 27, 28, 29, 45, 60, 82, 88, 96, 97, 117, 127, 134, 135, 138, 148, 149, 151, 156, 157, 166, 175.

W. W. Hamlyn, West Bend, Wis., tested cows Nos. 87, 133.

L. P. Martiny, North Freedom, Wis., tested cows Nos. 12, 13, 14, 17, 18, 22, 23, 25, 81, 89, 90, 93, 98, 99, 100, 128, 129, 131, 139, 140, 141, 142, 150.

Chas. A. Nicolaus, Troy Center, Wis., tested cows Nos. 1, 7, 8, 9, 10, 11, 19, 20, 21, 30, 31, 40, 41, 42, 47, 51, 52, 53, 54, 55, 56, 57, 65, 70, 71, 73, 74, 75, 79, 80, 85, 86, 108, 110, 111, 113, 116, 118, 119, 120, 121, 122, 125, 126, 130, 132, 143, 146, 147, 152, 158, 159, 167, 168, 172, 174, 176.

Roscoe H. Shaw, Manhattan, Kan., tested cows Nos. 4, 5, 6, 8, 9, 50, 78, 145, 146.

J. M. Wagner, Hillsboro, Wis., tested cows Nos. 2, 3, 15, 16, 26, 32, 37, 38, 39, 49, 58, 59, 61, 62, 63, 66, 72, 77, 83, 84, 91, 94, 101, 102, 106, 107, 123, 124, 136, 137, 153, 160, 161, 162, 163, 164, 165.

Official dairy tests of Holstein cows, 1901–1902.

CLASS I.—Cows five years old and over.

No.	NAME OF COWS.	Registry No.	Test began.	Age.	Days in milk.	Yield in Seven Days. Milk.	Yield in Seven Days. Fat.	Per Cent. Fat. Aver'ge	Per Cent. Fat. Range.	Fat per day, range.	Temperature of Cows. Aver'ge	Temperature of Cows. Range.
				Y. M. D.		Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	°F.	°F.
1	Gewina 2ds Lilly	40124	July 4	6—3—14	2	333.1	11.967	3.61	3.0 -4.6	1.52-1.87	....	....
2	Maid of Oak Grove Pietertje	45691	Sept. 11	5—6—24	88	354.3	10.590	2.99	2.4 -3.8	1.44-1.69	101.1	99.2-101.6
	Maid of Oak Grove Pietertje	45691	May 7	6—5—23	4	436.4	15.726	3.60	3.5 -3.8	2.06-2.50	101.4	101.2-1.6
3	Big Jane	43612	Sept. 11	7—6—6	7	363.2	13.220	3.64	2.4 -4.6	1.72-2.09	101.2	100.6-2.0
4	Netherland Rena Elbaje	41500	Oct. 1	5—8—0	14	275.5	10.205	3.70	3.1 -4.8	1.29-1.65	103.1	102.7-4.6
5	Netherland Elbaje	29861	Oct. 1	6—5—26	9	221.0	8.721	3.95	3.6 -4.25	1.17-1.30	102.7	102.5-2.8
6	Bell of Ringwood	38598	Oct. 1	7—1—28	30	305.9	10.006	3.27	2.35-3.77	1.18-1.63	102.4	102.0-2.8
7	Aaggie Green 3d	1382 W	Oct. 5	7—0—23	14	425.6	13.961	3.28	3.0 -3.7	1.91-2.03	....	....
	Aaggie Green 3rd	1382 W	Nov. 8	7—0—23	46	446.0	14.724	3.30	2.75-3.95	1.93-2.19	101.6	101.2-1.8
8	Hiawatha Maids 2nd Delle	28672	Oct. 9	9—5—27	11	386.8	12.145	3.14	2.5 -3.7	1.67-1.83	102.0	101.4-2.8
9	Aaggie Echos Justine	36121	Oct. 9	7—2—28	12	354.0	12.179	3.44	3.0 -4.5	1.66-1.79	102.5	102.2-3.0
10	Minnie Spaanz 2nd	38388	Oct. 20	6—5—9	66	283.3	11.135	2.90	1.8 -4.4	1.46-1.69	101.9	101.1-2.4
11	Bakker Belle 2nd	22528	Oct. 20	11—7—22	5	356.2	13.525	3.69	2.1 -6.2	1.69-2.29	102.0	101.8-2.8
12	Echo Pietertje Astrai	35315	Oct 24	9—3—6	12	433.6	15.206	3.51	2.6 -4.7	1.99-2.29	102.3	102.0-2.6
13	Daisy B. Mercedes	24703	Nov. 7	11—7—5	11	374.4	12.976	3.42	2.8 -4.3	1.59-2.08	102.5	101.8-2.8
14	Gracie G	45659	Nov. 7	6—1—7	6	321.7	10.731	3.31	2.7 -3.9	1.42-1.60	102.5	102.2-2.6
15	Johanna Rue 3rd*	42167	Nov. 9	5—6—21	21	491.2	19.392	3.95	3.0 -5.1	2.67-2.80	102.3	102.0-2.7
16	Colantha 4th†	35028	Nov. 9	8—8—9	13	543.3	18.713	3.44	2.2 -4.55	2.57-2.79	102.9	102.8-3.1
17	Rixa Dulcina Pietertje	42812	Nov. 24	5—0—14	5	336.0	11.222	3.34	2.95-3.8	1.44-1.76	101.9	101.4-2.2
18	Netherland Joh. Pauline	40583	Nov. 24	5—3—23	44	356.4	10.198	2.83	2.0 -4.1	1.35-1.74	101.4	101.2-1.6
19	Jennie Zula	46626	Nov. 24	6—1—14	9	375.4	15.243	4.06	3.4 -5.0	2.14-2.21	101.6	101.3-1.8
20	Rigtje 3rd	51786	Nov. 24	6—10—14	2	450.6	15.208	3.38	2.7 -4.0	2.14-2.25	102.0	101.6-2.4
	Rigtje 3rd	51786	Dec. 16	6—10—14	24	459.1	15.300	3.32	2.6 -4.6	2.11-2.24	....	....
21	Aaggie Colanthus	39503	Nov. 24	6—10—15	2	344.5	12.846	3.73	2.6 -5.3	1.76-1.97	101.7	101.4-2.4
22	Queen Echo	22348	Dec. 10	12—2—3	13	284.5	10.031	3.51	2.4 -4.4	1.32-1.56	101.8	101.4-2.4
23	Blanche Belle	38662	Dec. 10	7—2—29	8	387.4	13.818	3.57	2.8 -4.0	1.92-2.07	102.4	102.2-2.6
24	Edna Snowflake	37318	Dec. 16	7—0—28	12	365.1	14.090	3.91	3.0 -5.1	1.95-2.17	....	....
25	Johanna De Pauline	42169	Jan. 15	5—4—4	9	416.5	16.758	4.02	2.6 -5.3	2.30-2.65	103.2	103.0-3.4
26	Bakker Belle Pietertje	41995	Jan. 11	5—9—28	6	425.8	16.020	3.76	3.05-5.5	2.14-2.41	101.8	101.1-2.6
27	Fyra Pietertje May	36386	Jan. 21	7—8—1	15	376.7	13.101	3.48	2.85-4.15	1.78-2.05	....	....
28	Katydid Kweene	38699	Jan. 21	7—2—23	11	389.1	13.679	3.52	2.85-4.65	1.84-2.05	....	....
29	Pearl of Spring Brook	27736	Jan. 21	10—8—11	4	403.1	16.165	4.01	3.05-5.45	2.03-2.41	....	....
30	Daisy Oak Lawn	38596	Mar. 16	9—4—27	12	305.4	12.246	3.94	3.4 -4.4	1.63-1.92	....	....

* Awarded sixth prize. † Awarded eleventh prize.

31	Netherland Ida	41501	Mar. 16	6— 1—14	5	295.0	16 063	5.45	3.4 -7.4	1.92-2.85	102 3	102.0-2.8
32	Wit Duchess *	43953	Jan. 25	5— 5 — 5	6	445.6	19.904	4.47	4.23-4 78	2 59-3.01	101.9	101 6-2.1
33	Wild Rose Jones 2nd	37839	Feb. 15	7— 8—12	40	512 5	17.640	3.25	2.9 -3.7	2.45-2.63	101.7	101.2-2.4
	Wild Rose Jones 2nd	37839	June 10	8— 0—28	129	467.6	15.734	3 36	3.02-3.70	1.96-2 46	101.5	101.3-1.6
34	Jessie Fobes 4th	35692	Feb. 15	7—10— 1	35	608 7	15.760	2.58	2.3 -3.0	2.13-2.43	101.2	100.4-2.0
35	Jessie Fobes 2nd Tritomia †	44130	Feb. 15	5— 1—27	25	593.2	17.928	3.02	2.75-3.4	2.48-2 61	101.9	101.6-2.3
36	Alcartra 2nd Rose	44430	Mar. 15	8—10—22	20	388.9	14.210	3.65	2.8 -4.7	1.88-2.28	102 3	102 0-2.5
	Alcartra 2nd Rose	44430	Apr. 4	8—10—22	40	386.5	13 696	3.54	2.5 -4.8	1.87-2.01	101.8	101.4-2.5
37	Kakenstein	43974	Feb. 26	5— 2—13	9	385.3	16.237	4.21	3 6 -4.8	2 39	101.8	101.3-2.2
38	Piebe Laura Inka	41993	Feb. 26	5—11— 0	6	355.3	15.676	4.41	4.1 -4.8	2.14-2.36	101.4	101 2-1 6
39	Rixa Silva 3ds Pietertje	37258	Feb 26	8— 0— 9	6	420.7	15 970	3.72	3.44-4.45	2 16-2.46	102.7	101.5-5.0
40	Wisconsin Bess	45146	Apr. 4	6— 7— 0	12	451.3	16.096	3.56	1.9 -5 0	2.13-2.47	101.7	101.5-1.9
	Wisconsin Bess	45146	May 4	6— 8—18	49	467.7	16.089	3.41	2.2 -4.2	1.96-2.41	....	....
41	Kate Colanthus	43144	Apr. 8	5— 4—10	10	495.4	15 209	3.07	2.3 -4.2	2 00-2.31	....	....
42	Fyke Mechthilde	43855	Apr. 8	5— 4—12	20	400.9	12.480	3.11	2.4 -4 4	1.57-1.96	....	....
43	Piebe 5th	35246	Apr. 17	8— 6—14	13	437.2	15.340	3.51	3.32-3.90	2 08-2 30	101.4	101.1-1.7
44	Heilo 4th Pet	43611	Apr. 17	6— 6—26	15	505.6	17 976	3.55	3.32-3.78	2.47-2.65	100.6	100.5-0.7
45	Skylark Hendricka	46154	May 4	5— 0— 5	21	396.2	13.450	3.40	2 8 -4 1	1.81-2.01	102.8	102.6-3 0
46	Inka Pietertje Beets	42024	May 7	6— 1—19	17	395.6	12.900	3.26	3.2 -3.3	1.73-1.92	101.1	101.0-1.3
47	Bessie Wayne Champion	44179	May 20	6— 8—21	60	346 3	13 445	3.88	2.6 -6.2	1.77-2.17	103.0	102.3-4.2
48	Lady Oak 2nd	39947	June 10	7— 2—26	14	492.9	17 189	3 48	3.0 -4.55	2 26-2.53	101.7	101.4-2.0
49	Johanna Wit	44785	May 14	5— 1— 0	3	301.9	15.594	5.11	4.41-6.66	1.97-2.43	103 3	102 3-5.2
	Average for 55 tests	....	....	....	20	401.5	14.275	3.56	1.8 -7.4	1.17-3 01	102.0	99.2-105 2

CLASS II.—Cows four years old and under five.

50	Lill Blacks Johanna DeKol	2181W	Oct. 1	4— 0— 1	4	251.6	12.012	4.77	4.0 -5.4	1.44-1.87	102.3	101.8-2.8
51	Lady Longfield 4th	44125	Oct. 20	4— 9— 0	47	377.2	13.968	3.70	2.6 -6.3	1.73-2.46	101 5	100 8-2 8
52	May Ormsby	46453	Oct. 20	4— 3— 7	88	339.3	11.457	3.38	2.2 -5.4	1.41-1.82	101.6	100 8-2.0
53	Lady Dora Thorn 2nd	44127	Oct. 20	4— 8—20	56	331.6	12 013	3 63	2.8 -5.2	1.65-1.74	101.6	101 0-2.0
54	Duchess Ormsby's 3ds Butter Girl	49079	Oct. 20	4— 1—21	107	279.9	10 102	3.61	2.6 -4.95	1.33-1.55	101.3	101.0-1.4
55	Fyra Pietertje May 2nd	43168	Nov. 2	4— 9—28	18	396 4	12 925	3.26	2 0 -4.6	1.79-1.93	101.9	101.8-2.2
56	Aaltje Nettie	46801	Nov. 2	4— 2— 4	48	325.9	10.999	3.37	2.2 -4.6	1.43-1.62	102.1	101.8 2.4
57	Aaltje Rosa	46651	Nov. 2	4— 2—23	34	359.5	12 038	3.35	2.7 -4.4	1.66-1.79	101.9	101.6 2.6
58	Johanna DeKol 2nd	42168	Nov. 9	4—10—11	33	523.7	19.229	3.67	2.7 -4 4	2 65-2.91	102.2	101.7-2.6
59	Johanna Rue 4th	45166	Nov. 9	4— 0—28	21	402.5	13.490	3.35	2.7 -3 85	1 61-2.12	102.8	102.6-3.1
60	Daisy A. Mercedes 4th	46839	Nov. 27	4— 1—23	14	353.3	11.676	3 30	2.4 -4.9	1.51-1.85	102.5	102.4-2.6
61	Piebe Queen 2nds Princess	45007	Dec. 19	4— 9— 0	3	403 2	17.475	4.33	2.8 -6 45	2.12-2.60	102.6	102.1-3.0
62	Busacker	43980	Jan. 11	4—10—19	10	320.0	12.720	3.98	3 0 -4.9	1.75-1.87	102.7	102.2-3.3
63	Akkrummer Aaggie Beck	44677	Jan. 11	4— 7—22	47	250 3	10 470	3.74	2.9 -5.7	1 37-1.66	101 7	101.4-2.1
64	Lady Oak Fern‡	44126	Jan. 16	4—10—16	19	521.1	18.679	3 58	2.8 -4.65	2.48-2.94	101.8	100.4-3.1

* Awarded fifth prize. † Awarded fourteenth prize. ‡ Awarded second prize.

Official dairy tests of Holstein cows, 1901-1902 — Continued.

CLASS II.— Cows four years old and under five — Continued.

No.	NAME OF COWS.	Registry No.	Test began.	Age.	Days in milk.	Yield in Seven Days. Milk.	Yield in Seven Days. Fat.	Per Cent. Fat. Aver'ge	Per Cent. Fat. Range.	Fat per day, range.	Temperature of Cows. Aver'ge	Temperature of Cows. Range
				Y. M. D		Lbs.	Lbs	Lbs.	Lbs.	Lbs.	° F.	° F.
65	Acometh Tritomia 2nd	52521	Mar. 16	4—1—15	5	365.1	13.114	3.59	2.2-7.8	1.66-2.37	102.6	102.4-2.8
	Acometh Tritomia 2nd	52521	Apr. 8	4—1—15	21	390.6	11.781	3.02	1.8-4.0	1.52-1.93	.....	....
66	Netherland Minnie	46876	Jan. 25	4—3—21	13	345.0	12.592	3.65	2.1-5.75	1.76-1.84	102.5	101.6-3.6
67	Blanch Frisby	44133	Feb. 15	4—11—24	15	349.5	12.460	3.56	2.8-4.25	1.52-2.04	101.2	101.0-1.8
68	Grace Fayne 2nd	44124	Feb. 15	4—11—24	57	470.4	16.080	3.41	2.9-4.2	2.10-2.62	101.9	101.5-3.2
69	Jessie Griepe	44153	Mar. 15	4—10—26	37	381.8	12.970	3.40	2.8-4.15	1.78-1.99	101.5	101.0-2.0
70	Dorothy Pauline DeK. Wayne*	45123	Mar. 26	4—2—12	16	524.1	16.203	3.09	2.65-4.0	2.19-2.42	....	....
71	Canary's Mercedes Victoria	43780	Mar. 26	4—4—12	178	277.7	9.331	3.36	2.9-4.4	1.25-1.41	....	....
72	Jessie Fobes 2d's Myrtle	49192	Feb. 26	4—4—28	7	437.9	15.409	3.52	3.32-3.73	2.07-2.33	102.0	101.7-2.2
73	Hannah Melchior	43017	Apr. 8	4—8—19	18	490.9	14.684	3.00	2.2-4.3	2.00-2.30	....	....
74	Mantel 8ths DeKol	41744	Apr. 8	4—5—7	12	329.3	12.027	3.65	2.9-4.4	1.67-1.76	....	....
75	Lady Aaggie Netherland	50008	May 20	4—7—8	24	401.0	12.941	3.23	2.6-3.9	1.77-1.95	101.4	101.2-1.7
76	Gracia Ward	49517	June 10	4—1—7	173	411.3	15.214	3.7	3.4-3.92	2.14-2.28	101.4	101.3-1.6
77	Estella Piebe	46800	May 14	4—8—11	18	398.5	14.940	3.75	3.66-4.04	1.96-2.29	102.9	101.8-5.6
	Average for 29 tests	......	....	....	38	380.6	13.412	3.52	1.8-7.8	1.25-2.94	102.0	100.4-5.6

CLASS III.— Cows threeyears old and under four.

No.	NAME OF COWS.	Registry No.	Test began.	Age.	Days in milk.	Yield in Seven Days. Milk.	Yield in Seven Days. Fat.	Per Cent. Fat. Aver'ge	Per Cent. Fat. Range.	Fat per day, range.	Temperature of Cows. Aver'ge	Temperature of Cows. Range
78	Lucianna Netherlands Best	49448	Oct. 1	3—2—0	13	307.9	9.92	3.22	2.8-4.0	1.27-1.55	102.4	101.6-3.0
79	Aaggie Green Mercedes	50521	Oct. 5	3—11—23	24	421.5	14.685	3.49	3.0-4.2	1.96-2.27	101.8	....
80	Mercedes Aaggie Woodland	50521	Oct. 5	3—11—21	102	392.0	10.786	2.75	2.45-3.0	1.49-1.60	101.2	....
81	Lady Jettine Artis	48880	Oct 24	3—11—11	8	301.1	10.366	3.46	2.6-4.5	1.35-1.60	101.9	101.9-2.0
82	Buffalo Queen Mercedes†	51256	Nov. 8	3—11—24	10	364.6	15.568	4.27	4.2-5.35	2.12-2.32	102.1	102.0-2.4
83	Johanna DeKol 3d	45167	Nov. 9	3—10—15	41	381.3	14.799	3.88	2.85-4.9	2.08-2.16	101.7	101.4-2.1
84	Jessie DeKol Burke	44122	Nov. 9	3—9—21	9	450.7	15.177	3.37	2.55-4.1	2.01-2.27	102.8	102.8-3.1
85	Jennie Van Beers	49447	Nov. 24	3—4—3	7	391.6	14.571	3.73	2.6-4.9	1.95-2.22	101.6	101.4-1.8
86	Aurora Barbetta	51939	Nov. 24	3—8—11	15	323.3	11.275	3.49	2.75-4.2	1.57-1.65	101.2	100.8-1.4
87	Bessie De Kol Rue‡	49766	Nov. 23	3—1—6	22	42[illegible].1	15.208	3.57	3.0-4.8	2.03-2.23	101.8	99.2-102.8
88	Hendrika Mercedes Pietertje†	49870	Nov. 27	3—3—5	14	383.8	15.120	3.94	3.15-5.55	2.10-2.33	102.2	102.0-2.4
89	Ava Colanthus	50033	Dec. 10	3—4—9	6	320.1	12.057	3.77	2.8-4.6	1.58-1.88	102.0	101.2-2.6

* Awarded first prize. † Awarded fifth prize. ‡ Awarded fourth prize.

90	Lena Netherland DeKol	50026	Dec. 10	3— 1—25	7	330.7	13.839	4.18	3.65-4 6	1.94-2.05	102.1	101 6-2.9
91	Mechthilde Mink	47822	Dec. 19	3— 4—15	7	316.7	11 110	3.51	2.6 -5.0	1.52-1.63	102.6	102.5-2.7
92	Pearl Colantha Barbetta	52099	Dec. 16	3— 7—12	102	339.9	11.519	3.38	2.85-5.7	1.49-1.74	....	....
93	Johanna De Pauline 2d	48576	Jan. 15	3— 1—25	42	435.9	14.107	3.24	2.7 -3.8	1.98-2.03	101.9	101.8-2 0
94	Linda Laura	50023	Jan. 11	3— 1— 3	14	369.6	12.793	3 46	2.6 -5.15	1.69-2.00	101.9	101.5-2.5
95	Aaltje Salo Rika *	49337	Jan. 16	3— 1—12	18	461 6	14.910	3.23	2.6 -4.2	2.05-2.19	102.2	101.5-2.8
96	Ringwood DeKol †	47820	Jan. 21	3— 4—13	23	401.5	14.812	3.66	2 85-4.40	2.03-2 16	....	....
97	Aagie DeKol of Oak Grove	50497	Jan. 21	3— 1—29	12	357.0	12.358	3.46	2 6 -4.1	1.73-1.85	....	....
98	Gewina Lulu Snowball	48169	Feb. 2	3— 9—15	20	316.2	13.727	4.34	3.6 -5.55	1.91-2.02	101.3	101.0-1.6
99	Fanny Douglas 4ths Pet	48164	Feb. 2	3— 9—26	21	354.1	13.446	3.81	3.0 -5.0	1.75-2 25	101.7	101.0-2.2
100	Gewina Beauty Bell *	48167	Feb. 2	3—10— 1	20	435.4	15.363	3.53	3 0 -4.4	2.15-2 25	101 9	101 8-2.0
	Gewina Beauty Bell	48167	Mar. 15	3—10— 1	55	418.1	13.074	3.13	2.6 -3.8	1.74-2.03	101 8	101.5-2.5
101	Liscomb Aaggie 3d ‡	47553	Jan. 25	3—11—26	19	472 2	17.267	3.66	2.3?-5.8	2 21-2.64	101 9	101.5-2.3
102	Molly Mechthilde	50122	Jan. 25	3— 3—11	7	270.8	11.266	4.16	3.78-4.61	1.56-1.64	102.1	101.6-2.5
103	Myra Netherland	49519	Feb. 15	3—11—24	74	375.6	14.800	3.93	3.5 -4 5	2.04-2.20	101.6	101.0-2.1
104	Gracia Ward **	49517	Feb. 15	3— 9—24	21	508.6	17.655	3.47	3.05-4.2	2.42-2 62	102.8	102.6-4.3
105	Ollie Watson 5th	48168	Mar. 15	3—10— 0	24	372.7	12.959	3.48	3.3 -4.0	1.70-1.95	102 2	102 0-2.5
	Ollie Watson 5th	48168	Apr. 4	3—10— 0	44	398 2	13.272	3.33	2.7 -4.0	1.79-2.02	101.7	101.3-2.5
106	Flora Estata	50024	Feb. 26	3— 4— 6	4	313.4	12.063	3.85	3.74-4.00	1.64-1.83	102.1	101.4-2.7
107	Piebe Pietertje DeKol	47821	Feb. 26	3— 6—26	7	266 0	11.158	4.19	3.98-4.45	1.52-1.61	101.9	101.5-2.1
108	Alcartra Polkadot	50798	Apr. 4	3— 1— 6	8	370.8	16.262	4.38	3 8 -5.3	2.10-2.46	102.5	102.0-3.0
	Alcartra Polkadot ††	50798	May 4	3— 1— 6	39	459.8	17 280	3.76	2.6 -5.1	2.26-2.75	....	....
	Alcartra Polkadot	50798	May 11	3— 1— 6	46	480 3	15.222	3.17	2.4 -4.0	1.90-2.56	....	....
109	Francktje 2ds Maid	48163	Apr. 4	3— 8—14	16	356 4	12.870	3.61	2.9 -4.05	1.70-1.98	101 8	101.2-2.8
110	Canary Queen Lill	48257	Apr. 8	3—11—14	5	310.7	13.613	4.38	3.2 -6.0	1 66-2.33	....	....
111	Minnie Astrea	48573	Apr. 8	3— 1—11	2	185.7	5.269	2.84	1.7 -4 5	.56- .89	....	....
112	Butterfly Netherland	48763	Apr. 17	3—11—14	6	411.6	14.379	3.49	3 02-3.79	1.82-2.34	101.3	101.1-1.5
113	DeKol Douglas	50667	May 4	3— 1—12	23	375.4	13.039	3.47	2.9 -4.4	1.81-1.95	....	....
114	Rena Myrtle De Kol	51298	June 10	3— 4—3	31	366.9	11.500	3.13	2.87-3.72	1.48-2 00	101.4	101.3-1.6
115	Jessie Fobes 6th Violet	52118	June 10	3— 2—3	12	345.0	9.965	2.88	2.53-3.2	1.10-1.66	101.7	101.6-1.8
116	Zinclaria Mechthilde	50646	June 26	3— 2—28	13	358.4	10.749	3.00	2.77-3 40	1.41-1.71	101.9	101.6-2.5
117	Duchess Ormsby 2nd's Queen	48317	Aug. 20	3—11—25	6	290.3	11.979	4.13	3.42-5.53	1.43-2.28	102.7	102.1-3.1
	Average for 44 tests	....	....	....	23	370.2	13.253	3.58	1.7-6.0	.56-2.64	102.2	99.2-104.3

CLASS IV.—Cows two years old and under three.

118	De Kol Douglas	50667	July 4	2— 3—14	23	297 0	10.229	3 44	2 1 -6.0	1.18-1 90	....	....
119	Ollie Watson 3d De Kol	50665	July 4	2— 3—2	7	247.5	8.025	3.24	2.5 -4.0	1.09-1.20	....	....
120	Gewina 2d Lilly 2d	50670	July 4	2— 1—14	7	262.8	8 427	3 21	2.8 -3.6	1 12-1 31	....	....
121	Lady Watson	50669	July 4	2— 3—2	13	236.0	7.660	3 25	2 6 -4 0	1.03-1.19	....	....
122	Olive De Cola 3d	50666	July 4	2— 5—14	17	254.3	8.389	3.30	2.7 -4.1	1.10-1.29	....	....

* Awarded sixth prize. † Awarded seventh prize. ‡ Production for 30 consecutive days: 1937 lbs. milk and 69.35 lbs. fat; average test, 3.58 per cent.
** Awarded second prize. †† Awarded first prize.

Official dairy tests of Holstein cows, 1901-1902— Continued.

CLASS IV.—Cows two years old and under three—Continued.

No.	Name of Cows.	Registry No.	Test began.	Age.	Days in milk.	Yield in Seven Days. Milk.	Yield in Seven Days. Fat.	Per Cent. Fat. Aver'ge	Per Cent. Fat. Range.	Fat per day, range.	Temperature of Cows. Aver'ge	Temperature of Cows. Range.
				Y. M. D.		Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	° F.	° F.
123	Zoldusky De Kol Queen	52153	Sept. 11	2— 2—4	21	247.1	8 880	3.60	3.1 -4.6	1.21-1.42	101 7	100.9-2.6
	Zoldusky De Kol Queen	52153	Jan. 16	2— 2—4	149	219.8	7.740	3.52	3.3 -3.95	1.01-1.15	100.5	100.4-1.0
124	Lady De Kol Hattie	49845	Sept. 11	2—11—8	16	239 1	8.270	3.46	2.45-4.50	1 06-1.28	102 2	101.9-2 7
125	Aaggie Greene Sholton	50522	Oct. 5	2— 9—5	12	334.4	10.079	3.01	2.6 -3.7	1.34-1 56	....	....
126	Aaggie Greene Lady Artis 2d*	50525	Oct. 5	2— 9—7	3	347.3	14.065	4.05	3.3 -6.5	1.80-2.26	....	....
127	F. Tiny Greene 2d	51258	Nov. 8	2— 9—8	20	361.7	11 116	3.07	2.15-4.55	1.36-1.74	102.4	102.2-2.6
128	Madge P. De Kol	51195	Nov. 7	2— 6—23	8	329.3	10.482	3.18	2.65-3.6	1.42-1.58	102.3	102.2-2.4
129	Pietertje Maid of Grouw 2d	51194	Nov. 7	2— 9—3	9	329.5	11.413	3.47	2.9 -4.0	1.60-1.68	102.3	102.0-2.6
130	Piebe Estata 3d	52213	Nov. 13	2— 3—3	11	281.9	10 413	3.69	2.2 -6.2	1.40-1.58	102.4	102.2-2.6
131	Queen Artful Sholton	50526	Nov 24	2—10—16	15	303.3	9.194	3 03	2.2 -3 8	1.24-1.44	101.4	101 8-2.2
132	Ava Terzol of Lake Side	52917	Nov. 24	2— 1— 5	11	229.0	8.761	3.82	2.8 -4 7	1.16-1.30	101 6	101.5-2.2
133	Netherland Johanna DeKol	53131	Nov. 23	2— 2— 5	21	326.4	10.920	3.35	2.6 -4.0	1.44-1.69	101 9	100.4-2.4
134	Skylark Mercedes DeKol	53644	Nov. 27	2— 1—13	13	306 5	11.407	3.72	3.5 -4.05	1.52-1.71	102.6	102 4-2.8
	Skylark Mercedes DeKol†	53644	Dec. 3	2— 1—13	19	330.0	12 657	3.84	3.05-5.6	1.69-1.92	103.2	102.5-4.0
135	Daisy A. Mercedes 4ths DeKol	53641	Nov. 17	2— 1—12	19	321.4	10.498	3.27	2.75-3.95	1 45-1.56	102.9	102.5-3.2
136	Hengerveld DeKol Tritomia	53078	Dec. 19	2— 1— 7	20	251.5	9.018	3.59	2.15-6.0	1.02-1.45	101 6	101.3-1.8
137	Duchess Ormsby 4th	48504	Dec. 19	2—11—21	12	235.5	9.730	4.13	3.0 -6.0	1.33-1.44	101.4	101.1-1.7
188	Daisy Mercedes Pietertje 2nd‡	53643	Jan. 7	2— 1—29	15	386.6	12.658	3.27	2.45-7.95	1.67-2.06	....	....
139	Johanna Aaggie 3d	48579	Jan. 15	2— 8— 9	24	352.4	13.458	3.82	3 25-5.3	1.82-2.10	102.4	102.0-3.2
140	Johanna Sarcastic	52255	Jan. 15	2— 3— 6	44	269.8	9.727	3.61	2.9 -4.3	1.30-1.48	102.4	102 2-2.6
141	Johanna Clothilde 3d	52252	Jan. 15	2— 3—23	35	302.5	11.363	3.24	3.1 -4.55	1.55-1.66	102.5	102.2-2.6
142	Johanna DePauline 3d	52254	Jan. 15	2— 1—17	28	295.8	10.158	3 43	3.0 -4.35	1.42-1.49	102.1	101.6-2.4
143	Corona Cloth DeKol Girl	53731	Mar. 16	2— 3— 0	14	242.3	9.659	3.99	3.0 -4.9	1.34-1.46	....	....
144	Glen DeKol Artis	52748	Feb. 15	2— 4— 9	5	290.0	9.901	3.41	3.0 -3.9	1.37-1.44	101.8	101.6-2.2
	Glen DeKol Artis	52748	Mar. 15	2— 5— 8	32	337.2	10.620	3.12	2.75-3.6	1.47-1.56	....	....
145	Dolly VanBeers	51574	Oct. 1	1—11—13	16	245.2	8.92	3.63	2.55-4.2	1.20-1.35	102.8	102.4-3.2
146	Matina Maid's Pietertje DeKol	53062	Oct. 9	1—11—28	7	237.4	7.769	3.27	2 8 -4.0	1.04-1.16	103.0	102.5-3.8
147	Butter King Butter Queen	57281	Nov. 2	1— 7—21	10	268.1	9.234	3.44	2.35-4.3	1.24-1.38	101.8	101.8-2.0
148	Madge Mercedes Pietertje 2d	53647	Nov. 27	1— 9— 6	14	228.1	7.918	3.49	2.95-5 0	1.06-1.29	102.5	102.1-2.8
149	Pietertje Maid of Grouw 3rd	53646	Nov. 27	1—10—14	14	257.6	9.451	3.67	2.85-4.6	1.26-1.48	....	....
150	Inka Pietertje of Spring Brook	53979	Dec. 10	1—11—23	6	282.9	9.170	3.24	2.7 -4.2	1.25-1.42	101.5	101.4-1 6
151	Aaggie Pietertje Colanthus	53978	Jan. 21	1—11—19	31	240 6	7.684	3.19	2.55-3.7	1.07-1.14	....	....
152	Queen Ringwoods 2d Johanna	55034	Mar. 16	1— 7—23	10	182.2	6.299	3.51	2.6 -4.3	.84- .93	....	....

* Awarded fourth prize. † Awarded seventh prize. ‡ Awarded eighth prize.

153	Piebe Queen 5th	52152	Jan. 25	1—10— 3	16	221.1	9.577	4 33	3.6 -5 55	1.34-1.43	102.3	171.7-3.1
154	American Jewel	52747	Feb. 15	2— 5— 5	4	371.7	12.300	3.31	2.75-4.00	1.64-1.81	102.2	102.1-2.6
	American Jewel *	52747	Mar. 2	2— 5— 5	19	364.7	12.823	3.52	2.2 -4.7	1.79-1.88	....	....
	American Jewel	52747	June 10	2— 5— 5	179	338.9	11.414	3.36	3.18-3.62	1.45-1.70	101.5	101.3-1.6
155	Heilo Aaggie Joh. 3d	55020	Mar. 15	1— 5—29	48	172.5	6.635	3 85	3.4 -4.8	.90- .99	102.5	102.0-3.2
156	Hilda De Kol Clothilde	53790	Mar. 25	2— 3— 2	15	258.1	9.794	3.79	3.4 -4.35	1.26-1.51	102 0	101 8-2.1
157	Augusta Wit 2d	53791	Mar. 25	2— 4— 3	10	238.5	8.305	3 48	3.2 -4.2	1.14-1.28	102.0	101.7-2 3
158	Parmelia Mercedes of Lake Side	52915	Mar. 26	2— 2—28	11	251.4	8.599	3.42	3.1 -4.0	1.18-1.28	....	....
159	Veronica Aaltje of Lake Side	52914	Mar. 26	2— 5—19	19	275.1	9 877	3.59	2.6 -4.8	1.34-1.50	....	....
160	Frankie Melchior 3d	52248	Feb. 26	2— 1—18	7	294.9	10 024	3.40	2.99-3.96	1.32-1.57	101.5	100.6-2.0
161	Springvale Duchess 4th	52247	Feb. 26	2— 3— 7	7	281.7	10.480	3.72	3.55-3 84	1 43-1.50	102.3	101.6-2.8
162	Rixa Hengerveld De Kol	53075	Feb. 26	2— 1—21	5	247.8	9.530	3.85	3.58-4.16	1.29-1.44	101.7	101.4-2.0
163	Rijanetta Clothilde 2d	52246	Feb. 26	2— 0— 3	9	312.2	10.500	3.36	3 20-3 62	1 39-1.62	102 3	102.3-2.3
164	Duch. Ormsby 2ds Heng. De Kol †	53074	Feb 26	2— 1—29	3	348.5	15.212	4.36	3.3 -5.45	1.67-2.49	102.3	102 0-2.6
165	Dame Marjory De Kol ‡	53077	Feb. 26	2— 4—25	5	312.0	12.953	4.15	3 73-4.66	1 64-2.03	102 2	102.0-2.4
166	Butter Biscuit 2nd	53276	May 4	2— 7— 6	6	283.5	9.583	3.38	2.70-4.50	1 27-1.55	101.9	101.6-2.0
167	Pearl Gewina	55019	May 4	1—10—26	20	284.2	9.129	3 21	2.8 -8.6	1.23-1.40	....	....
168	Jessie Grippe 3rd	55014	May 4	2— 0—22	26	262.1	8.550	3.26	2.4 -4.15	1.11-1.31	....	....
169	Cherry Pauline Duchess	52922	May 7	2— 7—24	17	284.2	10.994	3.86	3.8 -4.12	1.51-1.62	101 9	101.4-2.8
170	Jessie Pauline	54717	May 7	2— 2— 4	33	245.3	7.376	3 00	2.74-3.2	0.97-1.14	101 0	100.9-1.2
171	Piebe Orleans Burke	55192	May 7	2— 3— 3	4	262.3	9.544	3.63	3.3-4.55	1.23-1.47	101.3	101.4-1.7
172	Boon Aaltje Salo Longfield	53918	May 20	2— 1— 6	25	249 5	8 773	3.52	3.00-4.25	1.30-1 35	101.9	101.8-2.2
173	Jessie Fobes 2nd Myrtle 2nd	52751	June 10	2— 5—27	89	310.3	8.992	2.80	2.78-3.10	1.23-1.31	101.3	101.2-1.4
174	Canary Mercedes Genevieve	55339	June 26	1— 9—21	11	257.4	9 604	3.73	3.56-3.94	1.38-1.46	102 3	101 6-2.8
175	Aaggie Gerben Jewel	53076	May 14	2— 6— 4	10	328.2	8.894	2.71	2.15-3.75	1.17-1.37	102.8	101.9-3.8
166	Canary Mercedes Fillpale	53353	July 4	2— 9— 2	9	294.5	9.595	3.26	2.4 -4.7	1.27-1.45	103.7	103.0-4.4
	Average for 64 tests	....	....	....	**21**	**282.1**	**9.851**	**3.49**	2.1 -8.6	.84-2.26	**102.1**	100.4-4.4

* Awarded fifth prize. † Awarded first prize. ‡ Production for 30 consecutive days: 1381.7 lbs. milk and 48.309 lbs. fat; average test, 3.53 per cent. Awarded fourth prize for seven-day record.

One re-test was made during the year at the request of Mr. S. Hoxie, Supt. of Advanced Registry, viz., of cow No. 31 owned by F. B. Fargo, of Lake Mills, Wis. The re-test was conducted for twenty-four hours by the writer, on March 27th to 28th. The results of this test confirmed those of the seven-day test given in the preceding table.

A larger number of cows were tested for a longer time than seven days, during the past year than heretofore, and the best seven consecutive days reported for entry in the Advanced Registry of the Holstein-Friesian Association. Only the seven-day records have, however, been reported in the preceding, thus making possible direct comparisons between the production of milk and of fat by the different cows tested.

Prizes offered by the Holstein-Friesian Association for the year 1901–2 were awarded to the cows included in the test as shown in the tables. The list of prizes includes four first prizes, two second, four fourth, four fifth, three sixth, three seventh, and one each of eighth, ninth, eleventh and fourteenth prizes. Twenty-four prizes in all were, therefore, awarded to Wisconsin breeders during the past year, out of a total of sixty-three offered by the Association.

It is not the purpose to discuss the results of the tests further at this time. The records of the production of the cows of this and other dairy breeds which are being accumulated on these tests will, it is hoped, form valuable material for study when the work has been been continued for a couple of years more. The call for men to conduct official dairy tests is increasing rapidly from year to year, thus indicating the practical importance of the tests to the breeders of the state. According to the rules governing the tests, the expenses of the tests are to be borne by the breeders, and over $1,800 were paid out by Wisconsin breeders for the services of our men during the past year. The expenses of the tests to our Experiment Station are, however, almost as large, and if the work grows as it now promises to do, it will not be long before we shall be unable to carry this load without a specific appropriation for the work, or without placing the whole expense in connection with the tests on the breeders who are directly benefited by them.

The rules governing these tests have been modified in two particulars during the past year, viz., by the addition of a rule concerning the registry of cows to be tested and another concerning the time limit during which a supervisor may continue work at the same farm. The rules as now promulgated have served the purpose in view in a very satisfactory manner during the past year; aside from the criticism of the brief duration of the tests which renders possible a forced high production of a cow that might not be able to maintain a high standard for a considerable portion of the period of lactation, there is only one point in which the tests are subject to criticism, and have been subjected to criticism by many dairymen and breeds, inside and outside of the Holstein Association. This is in not providing for a time limit when cows may be placed on the test after calving. It has been known for a considerable time to some breeders and observing dairymen that cows which are in a fleshy or fat condition at the time of calving will "milk off" this superfluous body fat during the first couple of weeks after calving and their milk will be abnormally rich in fat during this time; a decrease of one or two hundred pounds in the live weight of the cows in the interval from calving until a normal per cent. of fat is reached is no uncommon occurrence with cows in this condition. Taking advantage of this phenomenon, many breeders have placed their cows on the test within a couple of days from calving, while the cow is still giving colostrum milk and when she has in no way reached normal conditions after parturition. There are a number of cases on record where the average per cent. of fat in the milk of the cows for seven days has been one or more per cent. above the normal fat contents of the milk of the cow when the test was commenced within a few days after calving.

Efforts were made during the past year by leading Holstein-Friesian breeders and by persons having the good name of the Official Dairy Tests at heart, to have a time limit of ten or fourteen days after calving decided upon by the Association, so that cows shall not be put on a test until this time has elapsed, but the efforts were unsuccessful through the opposition of a few breeders who apparently were afraid that tests of cows owned

by them which were conducted under normal conditions would not equal those previously made. Unless the Association decides upon a time limit for the beginning of tests after calving during the present year, this and other Stations having the supervision of official dairy tests will be likely to adopt a rule to this effect, believing it to be for the best interests of the breeders and of the good name of the tests, that the official test shall show the maximum production of the cows under normal conditions, and not of the production when the cows give colostrum milk or bloody milk, as has sometimes been the case, or when they have to be lifted on to their feet in order to be milked. During the year 1900–'01 eighteen tests out of 120 were commenced at nine days from calving or less, and eleven tests began within a week from calving. Of the 192 tests of Holstein cows conducted during the past year, 56 were commenced before ten days had gone by since calving, and 32 were commenced within a week from calving. The tests of the twenty-four cows receiving prizes during last year began at more than seven days from calving in all but four cases, however, showing conclusively that the highest production of a cow is not ordinarily reached until after a period of time more than a week or ten days from calving has passed.

It cannot, therefore, be characterized as anything but a shortsighted policy to place a cow on a test within a few days from calving, aside from the objection to this practice on the grounds of cruelty to animals and of the misleading results which such tests are apt to give. So far as my observation goes, most of the best breeders feed their cows after calving in such a way that they will not reach their maximum production of milk or butter fat until about two weeks from the time of calving at the earliest.

The rules governing the dairy tests, which have been in force during the past two years, are given below, with minor changes suggested by the experience gained during this time:

A. RULES REGARDING THE CONDUCT OF TESTS OF DAIRY COWS, UNIVERSITY OF WISCONSIN, AGRICULTURAL EXPERIMENT STATION.

The Agricultural Experiment Station of the University of Wisconsin, working in conjunction with the Holstein-Friesian Association of America, will conduct official tests of registered Holstein-Friesian cows during the year 1902-3 on the following conditions:

1. All tests will be conducted by the representative of the Station. Not less than two weeks' notice of the desired test shall be given by the owner on a blank which will be furnished on application by the Station.

2. It is understood and agreed that the person for whom the test is made will pay all expenses in connection with the test. The compensation for the Station representative conducting the test shall be $2.00 per day for each day of the test. The person for whom the test is made will also pay the necessary traveling expenses and provide for the accommodation of the Station representative while conducting the test.

The Station representative will present a bill of expenses to the owner of the cow or cows tested on completing the test, and will send a duplicate of the same with his report to the Station. This bill must be paid to the Station by the owner before the report of the test is transmitted to the Association. The Station will pay the funds so received to its representative.

3. The Station will furnish its representative with the necessary apparatus to conduct the test. This will consist of

(1) A spring balance for weighing the milk.

(2) A Babcock tester and accompanying complete apparatus for testing the milk.

(3) A 25 cc. pipette for taking composite samples.

(4) A clinical thermometer.

(5) Blanks, affidavits, etc., for making the returns.

Sulfuric acid, fruit jars, and other materials needed on the tests are to be furnished by the breeder for whom the test is conducted.

4. The Station representative shall fill out all blanks furnished by the Station as required, and shall make oath before a notary public to such statements as are required by the Station in conjunction with the authorities of the Holstein-Friesian Association.

5. If required, the Station representative shall make a report on the kinds and quantities of feed given during the test, and on the description and measurements of the cow or cows tested.

He shall also, if required, take the body temperature of all cows tested once a day during the first three days of the test, preferably between 2 and 3 P. M., and likewise later on when it seems desirable to do so.

(6) Before a test is started the cow should be registered in the Holstein-Friesian Herd Book, or proper application for such registry should be made. If registered, the Station representative of the test shall satisfy himself that the cow answers the description given in the Certificate of Registry. If application for registry has been made and the certificate not yet received, the supervisor shall take a description of the animal and retain the same for comparison with the certificate when received.

In no case shall the Station representative certify under oath to a report of a test unless the cow answers the description of the animal as given in the Certificate of Registry.

(7) No Station representative will be detailed to conduct dairy tests at the same farm for more than thirty consecutive days, except where cows are entered on six-month tests, in which case the time limit shall be two months. The Station reserves the right to change the men detailed on the tests at any time before the expiration of the time limits here stated, when it is deemed desirable to do so. Assignments on tests will always be made with a view of economizing traveling expenses for the breeders, as has been the policy in the past.

The Station reserves the right to make public in its reports and bulletins, or by other means, any and all findings secured while conducting official tests.

B. DIRECTIONS FOR STATION REPRESENTATIVE IN CONDUCTING TESTS OF DAIRY COWS.

1. The Station representative shall be present at the last regular milking preceding the beginning of the test and shall satisfy himself that the cow is milked dry at that time. He shall note the hour at which this milking is made, and the final milking of the test must be made seven days later at the same hour.

2. He must be present at each and every milking during the test and satisfy himself that at the close of each milking the pail contains nothing but the milk drawn from the cow under test.

3. Under no circumstances can more cows than one undergoing test be milked at the same time. The Station representative must in every case be in position to observe the milker during the whole milking.

4. Immediately after the milk is drawn at each milking he will take charge of the pail and contents, will weigh the same on scales provided by the Experiment Station, and enter the exact weight of milk at once on his records. He will then take a correct sample of the milk for his own tests and for the composite sample to be sent to the Station, in accordance with the following directions.

5. As soon as the milk has been weighed it is thoroughly mixed by pouring it from one pail to another, or by means of a dipper, and a pint fruit jar is immediately filled about two-thirds full of milk for the test sample. The Station representative takes charge of and is personally responsible for this sample, which is kept under lock and key until tested. The test is proceeded with as soon as convenient after the milk has cooled to ordinary room temperature.

6. Fat determinations are always made in duplicate, and the average of the two determinations recorded on the record sheet. The sample taken of any one milking is not thrown away until a perfectly satisfactory test of the milking has been obtained. The Station representative will enter at once the results obtained on the proper blanks, in ink or indelible pencil, on completion of each test.

7. If any of the milk or the test sample from a milking is accidentally lost, the missing weight or the test credited to this milking is to be obtained by taking the average of all corresponding milkings during the whole test; that is, if e. g. the evening milking is lost or the test sample therefrom, the average of the weights or tests of all evening milkings during the seven-day test is taken as the yield or test for the one lost. It must be stated on the report that data so obtained are estimated and not actual.

8. *Composite-Test Sample.*—At the time the test of the milk is made, a sample comprising as many cubic centimenters of milk as the number of pounds in the milking is placed in a pint fruit jar containing a small quantity of preservative, for the composite-test sample to be sent to the Station when the test is completed. A 25 cc glass pipette for taking this sample is furnished in each outfit.

Each and every milking must contribute to the composite-test sample, in the proportion to the amount of milk yielded each time, which will be accomplished by following the methods given.

The Station representative will be responsible for the proper care of the composite sample, and will send it by express, charges prepaid, immediately on the completion of the test to Prof. F. W. Woll, Agricultural Experiment Station, Madison, Wis.

9. The Station representative is not at liberty to decide as to which stipulations contained herein are essential and which are not, but is required to observe these directions in all details. He shall report any irregularity or unusual occurrence in connection with the test which he may observe, and shall, in general, take all possible means to conduct a fair and equitable test of the cows placed under his supervision.

B. TESTS OF GUERNSEY COWS.

The tests of Guernsey cows conducted during the past year were made in conjunction with the American Guernsey Cattle Club. The rules adopted by this association call for one-day tests of all cows that are to be entered for yearly records on the Advanced Register of Guernsey cattle, the tests to be conducted once a month by a representative of an agricultural college or experiment station without previous notice to the owners. The cows in two herds were tested during the year, viz., nine cows owned by Geo. C. Hill & Son of Rosendale, and five cows owned by M. D. Cunningham, of Kansasville, Wis. The tests of the former cows were conducted each month from March, 1902, on and those of the latter from the month of April on. The March tests were made by J. D. Clarke, Milton, Wis., as our representative, the April, June, July, August and October tests were made by Roy T. Harris, of Warrens, Wis., while Chas. A. Nicolaus, Troy Center, Wis., conducted the May and September tests. The following tables give information as to the ages and dates of calving of the different cows, as well as the main results of the monthly tests.

Names of Guernsey Cows Tested, 1901-02.

Name.	Dropped.	Last Calf.
Cows owned by Geo. C. Hill & Son, Rosendale, Wis.		
1. Sukine, 10323	October 9, 1897	Oct. 4, 1901.
2. Tidy, 3839	January 13, 1898.	Oct. 23, 1901. Sept. 18, 1902.
3. Goldlined, 11425	September 14, 1898	Dec. 4, 1901.
4. Little Polly, 6564	April 9, 1890	Feb. 25, 1902.
5. Primrosedale, 8606	October 14, 1895	March 1, 1902.
6. Verna of Hazelwood, 11761	February 14, 1896	March 26, 1902.
7. Twilight Louan, 12484	October 27, 1899	March 23, 1902.
8. Daisy of Rosendale, 14271	March 12, 1900	April 18, 1902.
9. Miss Lillia, 14270.	March 21, 1898	May 17, 1902.
Cows owned by M. D. Cunningham, Kansasville, Wis.		
1. Seig, 6855	April 10, 1893	March 23, 1902.
2. Graph's Princess, 13037	March 19, 1900	May 23, 1902.
3. Do Seig, 11219.	July 30, 1898	July 23, 1902.
4. Fes Lip, 10621	March 11, 1898	Sept 21, 1902.
5. Fesca, 7619.	July 6, 1891	Oct. 9, 1902.

Tests of cows owned by Geo. C. Hill & Son, Rosendale, Wis.

DATE.	Milk.	Fat.		Milk.	Fat.		Milk.	Fat.	
	Lbs.	Per cent.	Lbs.	Lbs.	Per cent.	Lbs.	Lbs.	Per cent.	Lbs.
1902.	Sukine, 10323.			Tidy, 3839.			Goldlined, 11425.		
March 28	20 3	4.62	.939	20.7	5.13	1.073	18.0	4.37	.788
April 21	20.8	4.92	1 024	20 9	5.37	1.1 3	19.0	4.80	.912
May 30-31	23.9	5.12	1.224	21.6	5.45	1.177	17.3	4.32	.748
June 25-26	24.3	5.23	1.270	19.7	6.40	1.260	18.0	4.67	.840
July 17-18	14.8	5.59	.827	10.8	5.95	.643	12.0	5.04	.605
August 27-28	12 5	5.53	.691	......	......	....	9.5	5.43	.516
September 22	9.2	6.24	.574	26.5	4.10	1.086	6.8	5.87	.399
October 27-28	......	.....	....	24.5	4.65	1.139	......	......	....
1902.	Little Polly, 6564.			Primrosedale, 8606.			Verne of Hazelwood, 11761.		
March 28	26.4	4.57	1.209	......	......	....	......	......	....
April 21	26.1	3.76	.982	31.4	4.37	1 373	29 1	4.55	1.323
May 30-31	25.4	4.07	1.033	30.8	4.53	1.395	29.8	4.30	1.281
June 25-26	24.1	4.19	1.010	31 8	4.87	1.550	28.2	4 86	1.370
July 17-18	21 4	4.59	.982	15.1*	4.89	.738	20.7	5.06	1 047
August 27-28	20.1	4.34	.873	17.1	5.32	.909	21.0	4.37	.918
September 22	.....	......	....	14.8	5.20	.769	20.3	4.55	.914
October 27-28	......	......	....	......	......	....	18.3	4.68	.856
1902.	Daisy of Rosendale, 14271.			Miss Lillia, 14270.			Twilight Louan, 12484.		
May 30-31	25.8	3.88	1.002	30.9	4.66	1.439	28.4	4.24	1.204
June 25-26	22.8	4.17	.950	26.4	4.66	1.230	26.7	4.79	1.280
July 17-18	20.0	4.10	.819	22.2	4.89	1.086	19.9	5.55	1.105
August 27-28	18.2	4.14	.754	17.2	4.92	.847	20.2	4.71	.951
September 22	18 0	4.10	.738	17.6	4.81	.846	17.5	5.15	.902
October 27-28	13.7	4.53	.621	14.1	5.38	.758	13.8	5.36	.740

* One quarter injured shortly before the test.

Tests of cows owned by M. D. Cunningham, Kansasville, Wis.

DATE.	Milk.	Fat.		Milk.	Fat.		Milk.	Fat.	
	Lbs.	Per cent.	Lbs.	Lbs.	Per cent.	Lbs.	Lbs.	Per cent.	Lbs.
1902.	Seig, 6355.			Graph's Princess, 13037.			Do Seig, 11219.		
April 23-24	33.0	5.03	1.659	......	......	....	......	......	....
May 29-30	30.5	4.69	1.429	....	......	....	......	......	....
June 28-29	29 6	5.00	1.480	....	......	....	......	......	....
July 20-21	23.9	4.97	1.187	22 8	4.96	1.131	......	......	....
August 14-15	23 1	4.05	.934	24.8	6.13	1.517	32 3	5.45	1.761
September 23-24	19.1	4 70	.897	18 0	5.08	.913	22.2	5 25	1.166
October 30-31	18.5	4.09	.757	18.2	5.99	1.090	21.3	5.25	1.118
1902.	Feslip, 10621.			Fesca, 7619.					
September 23-24	25.7	5.42	1.391	......	......	....			
October 30-31	30.4	4.19	1.274	32.5	4.44	1.443			

C. TESTS OF JERSEY COWS.

During the past year one progressive Jersey breeder in the state has had similar tests conducted of cows in his herds as arranged for by the American Guernsey Cattle Club, eight tests being conducted from March, 1902, up to the present time. In addition seven-day tests of eight cows in the herd owned by the same breeder, Mr. F. H. Scribner of Rosendale, Wis., were made, May 30th to June 8th, 1902. The latter tests were conducted by Chas. A. Nicolaus, while the monthly tests were in charge of the supervisors who made the corresponding Guernsey tests. Ten different cows were tested in all on the monthly tests. The results of both the monthly and the seven-day tests with information concerning the cows tested are given below.

Names of Jersey Cows Tested, 1901-02.

Name.	Dropped.	Last Calf.
1. Loretta D., 141708	October 3, 1896	March 11, 1902.
2. Edith's Faith, 69724	May 7, 1890	March 24, 1902.
3. Belle's R's Sister 2nd, 106902	November 16, 1894	March 1, 1902.
4. Avileur, 103840	December 15, 1894	March 7, 1902.
5. Mabellena, 107603	December 15, 1894	April 2, 1902.
6. Lady Meroe, 152987	March 23, 1900	April 2, 1902.
7. Loa, 107279	May 19, 1894	May 6, 1902.
8. Buttercup of Prospect, 164158	August 20, 1896	May 27, 1902.
9. Ida of Rosendale, 152983	October 20, 1899	July 27, 1902.
10. Deoines Model, 148364	September 12, 1898	Oct. 22, 1902.

Seven-day tests of Jersey cows.

NAME AND REG. NO.	Age.	Days in milk	TOTAL PRODUCTION.		PER CENT. FAT.		FAT PER DAY.	
			Milk.	Fat.	Av.	Range.	Av.	Range.
	Y. M. D.		Lbs.	Lbs.			Lbs.	Lbs.
Edith's Faith, 69724	12—0—24	9	272.3	15.570	5.72	4.9 -6.6	2.22	2.03-2.36
Loretta D. 141708	5—7—29	83	307 3	16.648	5 42	4.2 -7.2	2 38	1.96-2.87
Avileur, 108840	7—5—16	84	278.6	12.947	4.65	2 6 -6 65	1.87	1.74-2.00
Loa, 107279	8—0—12	25	280.1	15.077	5.38	3.7 -7.6	2 15	1.93-2 32
Mabellena, 107603	7—5—16	59	273 9	15.113	5.52	3.9 -6.7	2.16	2 02-2 36
Lady Meroe, 152987	2—2— 8	59	212.6	10 893	5.12	4.65-5.9	1.56	1.48-1.65
Mabel's Surprise, 123876	6—7— 9	73	246.1	15 193	6.17	5.1 -7.65	2.17	2.12-2.25
Deoine's Model, 148364	3—8—19	212	195 8	12.799	6.54	5.0 -7.65	1.83	1.62 2.04

Tests of cows owned by F. H. Scribner, Rosendale, Wis.

DATE.	Milk.	Fat.		Milk.	Fat.		Milk.	Fat.	
	Lbs.	Per Cent.	Lbs.	Lbs.	Per Cent.	Lbs.	Lbs.	Per Cent.	Lbs.
1902.	Loretta D, 141708.			Edith's Faith, 69724			Belle R., 109902.		
March 28-29	40.3	5 05	2.037	29.4	4.87	1.434	30.4	4.60	1.400
April 22	43.2	5.15	2.223	37.4	4.98	1.863	30.8	4 48	1.379
May 30-31	42 5	5.28	2 243	35.7	5.92	2 112	31 7	4.57	1.448
June 27-28	39.1	4 88	1.910	32.5	6.55	2.130	33.5	4.72	1 580
July 18-19	32.5	5.43	1.764	25.1	4.51	1.133	26.4	4.95	1.308
August 28-29	32.1	5.32	1.709	24.4	5.41	1.319	28.4	4.44	1 260
September 21	26.2	6.42	1.681	22.8	5.83	1.329	23.3	4.68	1 091
October 28-29	21.4	6 49	1.388	19.9	7.00	1.393	21 6	5.31	1.147
1902.	Avileur, 108840.			Mabellena, 107603.			Lady Meroe, 152987.		
March 28-29	40.2	4.90	1.971	.....	.....	....	.....	.....	....
April 22	39.4	4.37	1.721	35.0	5.67	1.986	26.7	5.07	1.355
May 30-31	41.1	5.48	2.254	36.8	5.32	1.960	28.4	4.75	1.349
June 27-28	37.4	4.47	1 670	35.6	5.62	2.000	28 4	4.75	1.350
July 18-19	27.8	4.05	1.126	28.3	5.29	1.498	27.7	5.88	1.623
August 28-29	28.2	4.15	1.171	29.6	5.35	1 583	23.4	4.45	1.041
September 21	23.3	4.27	.995	24.7	5.30	1.310	20.3	4.89	.993
October 28-29	21.0	4.52	.950	21.6	5.88	1.271	19.7	4.93	.972
1902.	Loa, 107279.			Buttercup of Prospect, 164153.			Ida of Rosendale, 152986.		
May 30-31	43.9	5.00	2.174	.....	.....	....	.....	.....	....
June 27-28	41.4	5 05	2.090	36.7	3.73	1.370	.....	.....	....
July 18-19	37.7	5.67	2.137	29.5	3.95	1.164	.....	.....	....
August 28-29	32.1	4.75	1.524	26 9	4.19	1.126	28 0	3.75	1.049
September 21	28.1	5.42	1.523	21.9	4 25	.931	23.4	5.59	1.307
October 28-29	25.8	5.32	1.373	20.1	4.62	.928	19.8	4.60	.911

In addition to these tests, Deoine's Model (148364) was tested October 28–29, 1902: Milk, 31.9 lbs.; fat, 1.573 lbs.; 4.93 per cent. of fat.

D. TESTS OF RED POLLED COWS.

The Union Stock Yard & Transit Co., of Chicago, Ill., arranged for a so-called Farmers' Cow Contest during the present year, in which prizes are to be awarded at the International Live Stock Exposition held in Chicago, November 29th to December 6th, 1902. In this competition three one-week tests at least two months apart were to be conducted by a duly authorized representative of an experiment station in the state in which the cow is owned, in case of cows whose dairy records for a period of nine months, are entered, and four similar tests were to be made in the case of cows entered for a twelve-month period. In awarding the prizes the rating

given is 25% on the individual excellence of the cow as a combined beef and dairy animal, 35% on the butter record of the cow, and 40% on the individual merit of the calf, the butter record to be determined by adding 16 2–3% to the pounds of butter fat produced by the cow during the period covered by the test.

Two entries on this contest were made of cows in this state, both pure-bred cows of the Red Polled breed, viz., the cow Batrize (No. 8330–E 11) owned by J. W. Martin, of Richland City, Wis., and Waxy (No. 11931–V 10) owned by A. Dutton & Son, Trempealeau, Wis. In addition to these two cows three Red Polled cows belonging to the former breeder were tested once or twice during the year, and one other cow belonging to the latter breeder was tested once, making a total of thirteen seven-day tests of six different cows. The first three tests of Batrize and the first two tests of Waxy were conducted by Roy T. Harris, while the fourth and third tests, of Batrize and Waxy, respectively, were conducted by Chas. A. Nicolaus.

Seven-day tests of Red Polled cows.

NAME AND REG. NO.	Age.	Days in milk.	TOTAL PRODUCTION.		PER CENT. FAT.		FAT PER DAY.	
			Milk	Fat.	Av.	Range.	Av.	Range.
	Y. M. D.		Lbs.	Lbs.			Lbs.	Lbs.
Batrize, 8330, E 11	9— 8—11	60*	209.5	6.960	3.32	2.95-3.60	.99	.95-1.04
Batrize, 8330, E 11	9—10—15	123	199.6	7.360	3.69	3.40-4.15	1 05	.99-1.14
Batrize, 8330. E 11	10— 1— 2	202	191.7	7.443	3 88	3.4 -4.5	1.06	1.02-1.14
Batrize. 8330. E 11	10— 3— 3	262	181.5	7.176	3.95	2.8 -4.3	1 03	.83-1.17
•Pretension, 12806, E 11..	5— 1—21	20	177.2	7 618	4 30	3.35-4.70	1.09	.93-1.23
Pretension, 12806, E 11..	5— 4— 8	96	120.5	4 800	3.99	3.1 -5.8	.69	.58- .81
Plum, 12789, K 25	5— 6— 8	64†	157.0	5.945	3.79	3.1 -4.3	.85	.78- .91
•Plum, 12789, K 25	5—11—22	138	162.9	5 810	3.57	2.9 -4.6	.83	.67-1.02
Dorothy 2d, 11179, A 1 ..	5— 5—14	36	223 9	8.374	3.74	3.6 -4.1	1 20	1.15-1.23
Waxy, 11931, V 10	5— 4— 9	138‡	174.6	6.664	3.82	3.05-4.5	.95	.88-1.08
Waxy, 11931, V 10	5— 6— 9	198	182.8	6.902	3 78	2.45-4.65	.99	.85-1.29
Waxy, 11931, V 10	5— 8—12	264	144.1	5.409	3.76	2 9 -4.6	.77	.64- .87
Glady's, 11281, U 5......	5— 5—13	58	213.2	8.599	4.03	3.5 -4.55	1.23	1.11-1 27

* Test began Feb. 21, 1902. † Aborted Feb. 25, 1902. ‡ Test began April 3, 1902.

The cow Batriz produced 9,007.9 lbs. of milk and 337.8 lbs. of fat during eleven months (Jan. 1–Nov. 30, 1902) and was awarded first prize, while Waxy received third prize, her record for nine months being 7,651 lbs. of milk and 287.6 lbs. of fat.

It will be noted that dairy tests of pure-bred cows of the following breeds have been conducted by this Station during the past year, viz., of the Holstein-Friesian, Guernsey, Jersey and Red Polled breeds. The present season opens with prospects of a larger demand for men to do this work of official testing of dairy cows than ever before. We shall be glad to conduct tests also of cows of other breeds than those represented during the past year and stand ready to make appointments for such tests for breeders in this state on short notice, under the general rules governing the tests given on pages 119–121 of the present report.

OBSERVATIONS ON THE USE OF ACID TESTS FOR MILK AND CREAM.

E. H. FARRINGTON.

The use of some test for determining the acidity of either milk or cream is, every year, becoming more common among buttermakers. They find that these tests help them in several ways. First, as a guide to show the rate at which cream sours during the ripening process. Second, as a means of measuring the acidity of the cream-ripening "starters," and, third, to show the acidity in milk received from the different patrons of a creamery.

The two methods generally used for making these tests are the Manns' Acid Test and the Farrington Alkaline Tablet test. The details of manipulation for operating these tests are usually well known by creamery buttermakers but the following observations as to some points regarding their use may prove of benefit and interest to them.

I. FROZEN ALKALI.

The liquids used in both the tests mentioned above are alkaline solutions. These solutions are often kept in the creamery without being especially cared for and it consequently happens that in cold weather they are sometimes frozen. A number of inquiries which we have received regarding this frozen alkali indicate that the users are somewhat bewildered about the effect which freezing may have had on the standard strength of the liquid. Some of them have thrown away their alkali after it had been frozen, thinking that the liquid was no longer fit to use. They doubtless get this impression from their results obtained by pouring out some of the liquid from

a bottle which contained ice. This liquid will not give the same results as were obtained before freezing, because it is stronger than the original solution; the freezing has caused a partial separation of the alkali. If, however, the ice is all melted before any liquid is poured from the bottle the completely thawed alkali will be of the same strength as it was before freezing.

The following simple test was made to show the effect which freezing may have on one-tenth normal alkali and on the standard tablet solution. Two portions, B and C, of about one pint each were poured from a two-quart bottle (A) of the alkaline solutions. The liquids B and C were then placed in a freezing mixture and frozen. The ice in bottle B was then all melted and mixed with the unfrozen part of the liquid. When bottle C was about one-half filled with ice the liquid portion was poured into bottle D and the remaining ice melted and kept in bottle C.

The acidity of a sample of sour milk was then tested by using each one of the four bottles of liquid in the same way: 17.6 c. c. of the sour milk only was measured out for each test. The following results were obtained.

No. of c.c. alkali solution used to neutralize 17.6 c.c. sour milk.

Bottle		Manns' Test. c. c.	Farrington Tablet Solution per cent. acidity.
A.	Original standard liquid	11.3	0.57
B.	Same as A, but frozen and then ice all melted	11.3	0.57
C.	Melted ice only	3[illegible]0	0.9
D.	Liquid poured off from ice	7.7	0.4

These results show that when standard alkali solutions are frozen, all the ice should be melted before the liquid is used and that if this is done the strength of these solutions is not impaired for testing the acidity of milk and cream. The original standard solution and some of the same after freezing and thawing gave identical results when both were used to measure the acidity of a sample of sour milk, but the liquid poured off

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from the ice was stronger and the melted ice was much weaker than the original solution.

II. CHANGES IN THE ALKALINE STRENGTH OF SOLUTIONS BY AGE.

In using the Farrington Alkaline Tablets for making the standard solution for testing the acidity of milk and cream, it has always been recommended that they should be dissolved in clean, soft water shortly before the tests are to be made. It has been found that fresh solutions of the tablets give correct results, but that the strength of old, stale solutions even when kept in tightly stoppered bottles is often impaired by age. The dry tablets will keep their standard strength indefinitely, but for some reason not yet determined, an aqueous solution of them does weaken by age. In order to get some idea of the length of time this solution will keep its standard strength a few observations have been made.

A quantity of tabet solution (5 tablets to 97 c. c. water) was made fresh each day for some ten days or more. These solutions of different ages were then used to test the same sample of sour milk. Buttermilk was generally tested in order to exaggerate as much as possible any change which age might have on the tablet solution. This change would be much more noticeable in samples requiring large amounts of tablet solution than is the case with those containing a low percentage of acid. The results of the tests are given in the following table:

Per cent. of acidity shown by the tablet solution of different ages.

Age of solution. (Days.)	Sample No.									
	A.	B.	C.	D.	E.	F.	G.	H.	I.	J.
Fresh	.52	.48	.53	.54	.57	.62	.65	.54	.59	.54
1	.52	.50	.54	.54	......	......	......	......	......	......
2	.52	......	......	......	......	......	......	......	......	......
3	.52	......	......	......	......	......	......	.55	......	......
4	.54	.52	......	......	......	......	......	......	......	......
5	.54	.53	......	......	.57	......	......	......	......	......
6	......	.54	......	......	......	.63	......	......	.64	......
7	......	.55	.59	......	......	......	.67	......	......	......
8	......	.55	.59	......	......	......	......	......	......	.60
9	......	......	.64	......	......	......	......	......	......	......
10	......	......	.62	.63	......	......	......	......	......	......
11	......	......	.61	.63	......	......	......	.60	......	......
13	......	......	......	.64	......	......	......	......	......	......
14	......	......	......	.63	......	......	......	......	.68	......
16	......	......	......	......	......	......	......	......	......	.66
17	......	......	......	......	......	......	......	.82	......	......
21	......	......	......	......	......	......	......	.82	......	......

These results show that no change of any consequence takes place in the tablet solution until it is a week or more old. Slight variations of the results in the second decimal place may be obtained even in duplicate tests of the same sample, and on account of this error in manipulations, which is present in any test, only differences in results of more than one-twentieth of one per cent. should be charged to the change in strength of the standard solution by age.

The table shows that sample A gave practically the same results, 0.54 per cent. acid, when it was tested with a tablet solution five days old, as was obtained with a fresh solution which gave 0.52 per cent. acid. Sample B tested 0.06 per cent. higher with a solution eight days old than with a fresh solution. Sample C tested 0.08 per cent. acid higher with an eleven-day old solution than with a fresh one. Sample H tested 0.28 per cent. acid higher with a three-weeks old solution than with a fresh one, and sample I tested 0.09 per cent. higher with a two-weeks old solution than with a fresh one.

In making comparisons of weak and of standard solutions, the higher tests indicate weak solutions, as the acid in a given quantity of the samples will require more of the weak than of the standard solution to neutralize it.

These results show that accurate tests may be made with a tablet solution freshly made or when the solution is less than a week old; if the solution is older than this, the results may come too high on account of a weakening of the strength of the solution by age. The dry tablets keep their standard strength indefinitely.

While making the above recorded observations it was noticed that accurate tests of acidity in cream, when using one-tenth normal alkali, or the solution used in the Manns' test, can only be obtained by emptying the burette of alkali each time after using it. Any exposure of this alkali by leaving the bottle uncorked or by allowing it to stand in the burette over night, weakened the solution and changed its standard strength. This change in strength while standing in the burette over night was noticed to be from 0.2 c. c. to 0.6 c. c., when 17.6 c. c. of sour skim milk was tested.

Table showing loss from weakening of alkali by standing in burette over night. 50 c. c. tested.

Sample No.	No. of c. c., Manns Alkali Required to Neutralize Sour Milk.	
	Fresh alkali.	Alkali left in burette over night.
1	45.7	46.8
2	31.9	35.5
3	52 0	52.5
4	53.4	55.1
5	53.4	55.4

The weakening of the alkali may be prevented by emptying the contents of the burette after each day's tests are made and by being careful always to use fresh solutions.

III. NECESSITY OF MIXING SAMPLES TO BE TESTED FOR ACIDITY.

It has long been a recognized fact among chemists that the curd or casein of milk acts as an acid toward alkaline solutions. This may be easily demonstrated by allowing a sample of milk to sour until the whey separates and then test the acidity of the whey and the curd separately. There is such a striking difference between the amount of alkali taken up by each of these two substances that the sampling of sour milk or cream becomes a very important matter.

The following observations illustrate this point: Samples of milk were allowed to sour until the curd separated from the whey. A 17.6 c. c. pipette full of each (curd and whey) was tested separately with one-tenth normal alkali. The following figures were obtained:

No. of c. c. $\frac{N}{10}$ Alkali required to neutralize the curd and the whey from the same sample of sour milk.

Sample.	No. 1.		No. 2.		No. 3.		No. 4.		No. 5.	
	C. C.	Pr ct. acidity.	C. C.	Pr ct. acidity.	C. C.	Pr ct. acidity.	C. C.	Pr ct acidity.	C. C.	Pr ct. acidity.
Curd — 17.6 c c...........	17.6	.9	16.8	.86	18.0	.99	19.4	.99	19.2	.98
Whey — 17.6 c c,........	12.3	.63	11.8	.60	13.7	.7	12.5	.64	12.6	.65

Samples number 4 and 5 were allowed to stand for eight days and the acidity of both curd and whey tested every two days in order to show that the whey would not reach the same acidity as the curd by continued souring. The number of c. c. of alkali solution required to neutralize 17.6 c. c. of each after standing eight days were as follows:

	Curd.	Whey.
Sample No. 4..................................	20.4 c. c. = *1.04 pr ct	12.3 c. c. = .63 pr ct.
Sample No. 5..................................	20.3 c. c. = 1.04 pr ct.	12.8 c. c. = .65 pr ct.

* Acidity.

These tests show that the curd and the whey of milk or cream even in the same sample will neutralize different amounts of alkali and it is, therefore, necessary to thoroughly mix each sample by pouring from one vessel to another before testing its acidity. They also show that the excess of acidity in the curd is not dissolved out by the whey and that they do not reach the same acidity even after being in contact with each other for several days.

IV. INFLUENCE OF RICHNESS OF CREAM ON THE ACID TEST.

The acidity which develops in milk and in cream comes largely from the milk sugar that is changed by fermentation into lactic acid. This is dissolved in the milk's serum. The butter fat which is a neutral substance is not dissolved in the serum* but is held in suspension. The butter fat must, how-

*The serum is that part of the milk or cream which is left when the fat is removed.

ever, be taken into consideration when the acidity of cream samples containing varying percentages of fat are compared. With milk the fat is not sufficient in quantity to have much effect on the acid test, but when the richness of the product increases to 30 or 40 per cent. fat, as in cream, the amount of neutral fat present is enough to interfere with a correct comparison of the acidity of the samples. The amount of serum in the same measured quantity of cream naturally varies with the fat. A 20 c. c. pipette full of cream with 20 per cent. fat, contains 16 c. c. of serum and the same quantity of 40 per cent. cream holds only 12 c. c. serum. It is evident, therefore, that since the acid is almost all dissolved in the serum, the comparative sourness of the two creams is not shown by simply testing the acidity of 20 c. c. of each one, but the amount in the 12 c. c. and 16 c. c. must be known. The richness or the per cent. of fat in cream should, therefore, be taken into account when the acidity of ripening cream is tested. This may be done by preparing a table which will show the acidity that should be developed in cream testing various percentages of fat in order to obtain a nearly uniform serum acidity in them all. The figures for such a table may be calculated by adopting some standard of acidity as, e. g., that cream containing 25 per cent. fat should test 0.6 per cent. acid when it is ready to churn; and then calculating the corresponding serum acidity of cream testing other per cents. fat. In 100 pounds of cream testing 25 per cent. fat there are 75 pounds of serum, and if such cream ought to test 0.6 per cent. acid when ready to churn, there must be 0.6 pounds lactic acid in the 75 pounds serum, or .008 pounds acid in 1 pound serum. The corresponding serum acidity in any other cream may be found by multiplying the pounds of serum in 100 pounds of each cream by .008. When such calculations are made the following table will be obtained:

Acidity of cream corresponding to .6 per cent. in cream testing 25 per cent. fat.

Cream fat, per cent	20	25	30	35	40	45	50
Serum, per cent	80	75	70	65	60	55	50
Acidity	.64	.60	.56	.52	.48	.44	.40

It is a well known fact that after the serum acidity has developed to a certain extent it stops, as the acid-forming bacteria will not grow in a serum containing much over .8 per cent. acid.

A few observations were made to illustrate this point and to show also the limit in per cent. of acidity that will develop in cream containing various per cents. of fat.

Different amounts of skim milk were added to some very rich cream so that the mixtures would contain from 25 to 50 per cent. fat. These, together with a sample of the skim milk used for diluting the cream, were left in a warm room to become as sour as possible. An acid test of each sample was made daily. The results obtained are given in the following table:

Showing the extreme acidity which developed in skim milk and in cream testing different per cents. fat.

Age of Samples When Tested.	Per Cent. of Acid in Samples.						
	Skim milk.	Cream testing per cents. fat.					
		25.	35.	40.	42.	45.	50.
Fresh	.17	.14	.14	.13	.13	.13	.11
24 hours	.55	.50	.38	.35	.34	.31	*
48 hours	.64	.57	.47	.46	.46	*	
72 hours	.76	.60	.53	.50	*		
96 hours	.78	.62	.54	.50			
108 hours	.78	. 0	.55				

* Too thick to draw into pipette.

These tests show that the acidity of the different samples reached a maximum beyond which it did not develop even though they were held under favorable conditions for souring. They also show that buttermakers should not expect cream containing 25 to 50 per cent. fat to develop an acidity beyond the figures given in the table. A cream containing 25 per cent. fat may reach 0.6 per cent. acid, but a richer cream such as a 40 per cent. fat cream will not sour much beyond 0.5 per cent. acid.

THE COMPOSITION OF FROZEN MILK.

E. H. FARRINGTON.

When milk is brought to a creamery in winter time it often happens that it is more or less frozen in the cans. This ice-milk may be a lump in the cover or a coating around the sides of the cans. The patrons sometimes think that this ice is simply the water of the milk and that their test ought not to suffer much on account of it, or, in other words, that they have brought just as much butter fat to the creamery when the milk is poured out and the ice left in the cans as is the case when the ice is melted and mixed with the milk before the cans are emptied. A few observations on this point were made to show what constituents of the milk were contained in the ice and how the composition of this ice differed from that of the milk before it was frozen. Trials were also made to show how the composition of the ice varied with the amount of ice present. About a pint of well-mixed milk was sampled for analysis. Some of the same milk was then measured into several jars and these were placed in a freezing mixture. The jars of frozen milk were taken out at different times so as to obtain varying proportions of ice. When removed from the freezing mixture the liquid milk was poured from the milk-ice. The amount of each was noted and analyses made of both the liquid portion and the melted ice. The chemical analyses were made by Geo. A. Olson, assistant in the chemical department of this Experiment Station. They show the composition of three samples of milk before freezing and of both the liquid portion and the melted ice from the frozen samples of the different lots of milk.

Analyses of frozen milk containing different amouuts of ic .

		Total solids.	Solids not fat.	Fat.	Casein.	Ash.	Milk sugar.
		Pr ct	Pr ct.	Pr ct.	Pr ct.	Pr ct	Pr ct.
Milk before freezing	Sample A	12.24	8.54	3.71	2.69	0 63	5.30
Frozen milk No. A1	Liquid, 80 per ct.	13.11	9.11	4.00	2.97	0.66	5.48
	Ice, 20 per ct.	9 43	6.76	2.67	2.3[illegible]	0.55	3 40
No A2	Liquid, 59 per ct.	12.41	8.67	3 74	2 55	0 64	5.47
	Ice, 41 per ct.	12.00	8 36	3.74	2.68	0.62	5.13
No. A3	Liquid, 46 per ct.	12.52	8.87	3.65	2.77	0.65	5 90
	Ice, 54 per ct.	12.00	8 25	3 81	2.46	0.61	4.60
Milk before freezing	Sample B	12.47	8.83	3.64	3 32	0 73	4 78
Frozen milk No. B1	Liquid, 72 per ct.	13 01	8.76	4.25	3.41	0 63	4.72
	Ice, 25 per ct.	11.00	8 71	2.30	3.15	0 61	4 95
No. B2	Liquid, 45 per ct.	13 05	9.36	3 67	3 84	0 65	4.87
	Ice, 55 per ct.	12 15	8.56	3.62	3 18	0 61	4.77
No. B3	Liquid, 74 per ct.	14 82	11.00	3 8[illegible]	3.81	0 74	6.45
	Ice, 26 per ct.	8.72	5 73	2.99	2 1[illegible]	0 43	3.77
Milk before freezing	Sample C	12.22	8.29	3.93	3.26	0.60	4.43
Frozen milk No. C1	Liquid, 56 per ct.	12 86	8 73	4.13	3.23	0.52	4.95
	Ice, 44 per ct.	11 86	8.22	3.64	3 20	0.63	4.34
No. C2	Liquid, 65 per ct.	12.61	8.45	4 16	3.23	0 52	4 70
	Ice, 35 per ct.	12.13	8.43	3.70	3.23	0.52	4.65
No. C3	Liquid, 76 per ct.	13.21	8 75	4.46	3 32	0 63	4 80
	Ice, 24 per ct.	10.23	7.90	2 38	2.94	0.59	4.37

These figures show the composition of frozen milk which contained about 20, 30, 40, and 50 per cent. of ice. When there was nearly 25 per cent. of ice in the milk the fat content of the frozen portion was about 1.00 per cent. less than that of the original milk, and the liquid portion which was poured off from the milk-ice tested about one-half a per cent. higher. When the milk was about one-half frozen or contained from 40 to 50 per cent. ice there was no great difference in the per cent. of fat found in the liquid and in the ice portion of the milk. The other constituents, casein, ash and milk sugar, were not separated very much by the freezing, there being about the same percentage of each in both the liquid portion and the ice from the same milk. These results show that the milk-ice left in cans contains nearly as much butter fat as the unfrozen milk and that if melted and fed to stock these receive about the same food as whole milk. They also show that the test of the liquid poured from the ice at the creamery will not be much higher than that of unfrozen milk.

PASTEURIZED CREAM BUTTER.

E. H. FARRINGTON AND J. H. GODFREY.

Pasteurization of cream for buttermaking is not commonly practiced in American creameries at the present time. A small amount of experimental work has been done in this direction, but the general impression among buttermakers seems to be that while butter made from either pasteurized milk or cream may be superior in keeping quality, it is inferior in flavor and in body to that of butter made from so-called raw cream, i. e., cream which has not been heated to the pasteurizing temperature. The opinion also seems to prevail that there is considerable expense connected with the making of such butter both on account of the extra fuel and machinery needed and the time required to operate the additional machinery. These impressions as to the quality and the additional cost of making pasteurized butter seem to have been accepted as sufficient cause for giving the matter little attention by the creamery industry of America.

One of the most common faults in our creamery butter is the lack of uniformity in its quality. This is a defect which if it can be overcome will pay for a considerable investment of time and money. Pasteurization of the cream seems theoretically to be a promising way of doing this. If butter flavor is the result of the action of certain fermentations in the ripening of cream, and if pure cultures of desirable fermentations can be obtained and planted in this cream, it is natural to expect these bacteria to thrive best in cream which has been freed from all other ferments. The cream as it comes from the separators contains a vast number of many kinds of bac-

teria, some of which are beneficial and others injurious to the butter flavor. When a pure-culture "starter" is added to such cream, the desirable bacteria have to contend with the many other kinds present and this mixture of bacteria will have a tendency to produce an irregular and sometimes an inferior flavor in the butter.

The possibility of making a uniform and desirable grade of butter seems, therefore, to be most certain when cream is pasteurized before it is ripened with a pure-culture starter. This theory of cream ripening has been generally accepted by good authorities. Some investigations as to its practical bearings were made in our Dairy School Creamery during the past season and are reported in the following:

The two points studied were, first, to observe the difference in quality between butter made from raw cream and from pasteurized cream when fresh and when several weeks old; and, second, to devise an economical and a nearly automatic way of heating and of cooling the cream as it comes from a separator.

These experiments were made between the months of April and July. This period included winter and summer-feed conditions of the cows producing the ten to fifteen thousand pounds of milk received daily at our Dairy School Creamery.

PLAN OF THE EXPERIMENTS.

The general plan of the experiments was to mix ten to fifteen hundred pounds of sweet cream from the separators in a large vat. This cream was then divided into three lots, A, B, and C. Some of the details of one experiment are given below; these will serve to illustrate the course pursued in all the others.

Lot A was cooled to about 50 degrees Fahrenheit and churned sweet. The acidity of the cream was about 0.3 per cent. and its test 30.0 per cent. fat. This churning required about one hour; the temperature of the buttermilk being 52 degrees F. and its test 0.1 per cent. fat. The granular butter was washed twice, the temperature of the water being 50 degrees F. The bulk of the butter was packed in tubs and four ten-pound pack-

ages also filled. The latter packages were numbered and placed in the refrigerator having a temperature of 45 to 50 degrees F. One package was sent to a commercial butter judge who was requested to score the butter when first received and to hold all packages in his cellar where the temperature ranges from 40 to 50 degrees F., and then to score them a second time in order to test the keeping quality of the butter.

Lot B was taken from the large vat and heated to 185 to 190 degrees F. in a continuous pasteurizer. The hot cream was run over a water cooler and cooled to 54 degrees F. It was then placed in a ripening vat, about 15 per cent. starter added, and warmed up to 75 degrees F. After the starter was added the cream tested 28 per cent. fat and 0.3 per cent. acid. Five hours later the cream had a temperature of 70 degres F. and 0.46 per cent. acid. It was then cooled and held over night and was churned the next morning at about seven o'clock. The temperature of the buttermilk was 56 degrees and its test 0.1 per cent. fat. Packages of this butter were saved as in the case of Lot A.

Lot C, the raw cream, was ripened with the same starter as was used in lot B. Lot C was held at about 75 degrees F. for three hours and at 70 degrees for two hours when it had reached 0.5 per cent. acid. It was then cooled and left to stand over night. The next morning this cream churned in forty minutes; the temperature of the buttermilk was 54 degrees F., and its test 0.1 per cent. fat. Packages of the butter were held in the refrigerator as mentioned under lot A.

The washing, salting and working of the three churnings from each day's cream were made as uniformly as possible, the point in the investigation being to note the differences there might be between sweet-cream butter, pasteurized-cream butter and raw-cream butter, all made from the same cream.

The packages of butter were examined every few days at the dairy school, and scorings were also received from the commercial judges. The following comments made by the writer about one set will illustrate the general quality of all the butter made in these three ways.

COMMENTS ON THE SWEET-CREAM BUTTER.

When one day old it had almost no aroma but a fresh, sweet-cream taste. Its texture was more like the pasteurized than the raw-cream butter; very little moisture showed on the surface and it had a close, solid body. After three days this butter had a suggestion of age in its aroma but the taste was still sweet. The butter remained in this conditon for three weeks, gradually getting a little more defective in aroma but still sweet to the taste. At that time the flavor was decidedly strong, like that of old butter. The flavor did not improve after the first day, but gradually showed its advancing age by becoming a trifle rancid rather than by developing a clean, sour taste.

COMMENTS ON PASTEURIZED CREAM BUTTER.

When this butter was one day old it had a clean taste, but not much aroma; it was rather flat but resembled the raw sour-cream butter more than that made from sweet cream.

After three days, more aroma developed and this continued to increase until the butter was three weeks old when the aroma changed somewhat, becoming a trifle sour. No other indication of age was shown until the butter was five weeks old when a slightly old taste began to be noticed. The texture of this butter was close, but not smeary, and fully equal to that of the raw ripened cream. The butter surface, however, showed almost no brine but looked dry and smooth, quite different from that of the raw-cream butter.

COMMENTS ON THE RAW-CREAM BUTTER.

The day after churning the flavor of the raw-cream butter was the highest of the three. The butter aroma increased a trifle each day for about two weeks when the butter began to show age, and in three weeks it was decidedly strong, almost rancid. The texture of this butter was coarser and more open than either that from the sweet or the pasteurized cream, and considerable brine showed in drops on the surface, making the appearance as well as the flavor of this butter decidedly different from that of the others.

A series of experiments similar to the one described were made occasionally during the summer, and the different kinds of butter from the same cream always showed the characteristics peculiar to the treatment of the cream.

The sweet-cream butter was at its best when made. It did not improve with age, but rapidly deteriorated, becoming decidedy off-flavor in three weeks' time. The pasteurized-cream butter was much better than the sweet-cream butter and its flavor inproved or became more pronounced until it was five weeks old. After about three weeks the flavor was fully as good as the fresh raw-cream butter and during this time very little, if any, objection could be made to it.

The body of this butter was not defective at any time. This is contrary to the general impression in this country about pasteurized-cream butter. In the opinion of the writer the method of heating and of cooling the cream directly after the heating as practiced in our experiment was responsible for the perfect body which this butter showed.

The raw-cream butter was at its best when first churned. It showed an aged flavor when two weeks old.

These characteristics of the three kinds of butter have been noticed before, but up to the present time very little pasteurized-cream butter has been made in this country. One reason for this, in my opinion, has been the lack of an economical and efficient method of heating and cooling the cream as it comes from the separator.

When a practical machine or apparatus for doing this work is provided I think the pasteurization of cream for buttermaking will become more general in our creameries as the process gives the buttermaker more control over his product than the methods of buttermaking now in use.

Pasteurized-cream butter holds its good qualities much longer than that made from raw cream; an acceptable flavor may be produced in it by the skillful use of starters, and the defects in body or grain, formerly noticed in pasteurized-cream butter may be overcome by using the improved methods of heating and cooling the cream.

DIFFICULTIES IN THE WAY OF DRAWING CONCLUSIONS FROM EXPERIMENTS IN BUTTER-MAKING WHEN BASED ON ONE JUDGE'S SCORES.

E. H. FARRINGTON.

When the butter used in the experiments described in the previous article was taken from the churn a number of packages were filled from each churning. There were usually three churnings in each experiment. All were made from one day's cream, but each lot of cream was treated differently from the other two lots. The packages of butter from each churning were numbered and one from each lot sent for scoring to a commercial butter judge. He was asked to inspect all packages when first received, to hold them in his cellar and re-score them at intervals of one week. In this way we hoped to get a trade opinion of sweet, of pasteurized, and of raw-cream butter, and also to learn how well the different kinds of butter would keep. When sending the different packages of fresh butter we often included in the shipment several packages of butter made in previous experiments, but which had been held in our Dairy School refrigerator. We had noticed that a judge always, unconsciously or otherwise, scores butter lower the second time than the first when he knows the butter to be some days older at the time of making the second score. Packages of butter were sent in the way stated to two commercial judges. Both judges as a rule pronounced the butter perfect on all qualities except flavor, but their scores on this quality were so different on the packages which they held and re-scored as compared with their scores on those which we held

and sent them with packages of fresh butter, that we concluded that the opinions of a single judge are apt to be confusing. The following figures show some of the flavor scores received on these packages of butter:

Judges's scores on the flavor of butter from the same churnings.

Series I. — Churned May 5.

Scored.	Age, days.	Raw Sweet Cream.			Ripened Pasteurized Cream.			Raw Ripened Cream.		
		No. 1.	No. 2.	No 3.	No. 4.	No. 5.	No. 6	No. 7.	No. 8.	No. 9.
May 14.	9 da.	35 A	......	......	40½A	.....	.....	40½ A	......	......
May 23.	23 da.	31 A	38 B	......	30 A	40 B	.....	34 A	39 B	......

Series II. — Churned June 16.

Scored.	Age, days.	Pasteuriz'd sweet			Ripened pasteurized Cream.			Raw ripened Cream.		
		No.10	No 11	No.12	No.13	No.14	No.15	No 16	No.17	No.18
June 19	3	39	.....	....	41	......	......	37	.....	......
June 30	14	..	41	......	......	35	......	....	38	......
July 15	30	30	33	....	32	30	......	31	35	......
July 22	37	.....	......	40	37	......	39	......	......	37

Series III — Churned June 24 —Weedy flavor.

Scored.	Age, days.				Ripened pasteurized Cream.			Raw ripened Creem.		
					No.19	No.20	No 21	No.22	No.23	No.24
June 30.	6	......	......	......	35	......	......	37	......	......
July 15.	21	.....	......	......	33	29	......	35	36	..
July 22	28	......	......	......	......	......	35	......	......	33
Aug. 6.	42	......	......	......	......	......	30	......	......	30

Series IV. — Churned July 1.

Scored.	Age, days.				Ripened pasteurized Cream.			Raw ripened Cream.		
					No.25	No.26	No.27	No.28	No.29	No.30
July 15.	14	......	......	......	42	......	......	37	......	......
July 22.	21	......	......	......	......	39	......	......	34	......

This table shows the scores of the two or three packages of butter from each churning. In the first series, packages Nos. 1, 4, and 7 from different churnings, were sent to judge A; he scored them 35, 40½ and 41½ on flavor when the butter was nine days old. After holding these packages until they were twenty-three days old, he scored them a second time, 31, 30, 34. These figures show a decline in quality as is usually found, but three packages from the same churnings were scored by judge B when they were twenty-three days old, he not knowing anything about the age of the butter, and his scores were, 38, 40, 39. It may be said that the last three packages had been kept in a more suitable place during the twenty-three days than the first three were kept, but the evidence will hardly bear out this opinion, since the temperature of both places was about the same and the ventilation good.

The second, third and fourth series of scores were made by the same judge. The sweet cream was pasteurized before churning in this experiment. The ripened pasteurized and raw-cream lots were treated as before described. The scores of the three packages from each churning show the same tendency as before The packages held by the judge always scored decidedly lower the second time than the first, as is usually the case, but the packages new to him from the same churnings were scored when five weeks old as high as the same butter when fresh. Packages 10, 11, and 12, from the same churning, scored 39, 41, and 40, when 3, 14, and 37 days old, respectively; but 10 and 11, which the judge held and inspected a second time, scored 30 and 33, when 30 days old. A similar tendency of the scoring was noticed in the other packages from the same churnings.

The butter in series III was made from cream which was strongly tainted with a weedy flavor. The scores show that the pasteurizing did not remove this taint. Other trials of the same sort gave similar results.

The differences in scores suggest that when important matters are at stake, the opinions of a number of judges working independently or in sets of three judges should be obtained; each tribunal making its report independently of the other,

and none of them knowing anything about the history of the butter scored.

Another point to be noticed in these experiments is the scores of the pasteurized-cream butter when freshly made. In nearly every case they were as high and sometimes higher than those of the raw-cream butter. This shows that the generally accepted opinion about pasteurized-cream butter being flat, insipid and lacking in flavor is not necessarily true. The making of pasteurized-cream butter requires more skill than simply running the cream from a separator into a vat and churning it the next morning. The buttermaker must be trained to this work which, when he has become proficient therein, will remove much of the haphazard element now common in American buttermaking.

A MODIFIED CREAM-TEST BOTTLE.

E. H. FARRINGTON.

The increased interest in cream testing during the past two years has brought out several new cream-test bottles. This has been largely caused by the extensive use of farm separators and furnishing cream instead of milk to the creameries.

The testing of cream as a means of determining the amount of butter fat sent to a creamery by its patrons is a much more difficult process than the testing of whole milk, because the percentage of fat being larger in cream than in milk the errors of testing are greater; the amount of fat separated is often six times as great from cream as from milk. Experiments have shown that it is not safe to measure the cream into the test bottle with a pipette as milk is measured, on account of the condition of the cream. The cream, furthermore, does not drain from the pipette so completely as milk on account of its thickness and viscosity. These two facts make it impossible for a 17.6 c. m. milk pipette, which delivers 18 grams of milk to measure out this weight of cream. It is therefore necessary to weigh the cream into test bottles in order to determine accurately the percentage of fat in different samples of cream.

Without discussing this part of the question further, the point I wish to draw attention to in this article is the construction of the cream-test bottle. Manufacturers have been placing cream-test bottles on the market for a number of years. They are made of the same length as the milk-test bottles, and while the bulbs of the two bottles are about the same size the neck of the cream bottle is much larger in diameter. This gives an opportunity for testing as much as 30 per cent. fat in

the cream-test bottles when 18 grams of cream are used. For some unknown reason the manufacturers have been gradually increasing the diameter of the neck, thus contracting the length of the scale on the cream-test bottles so that in some cases the

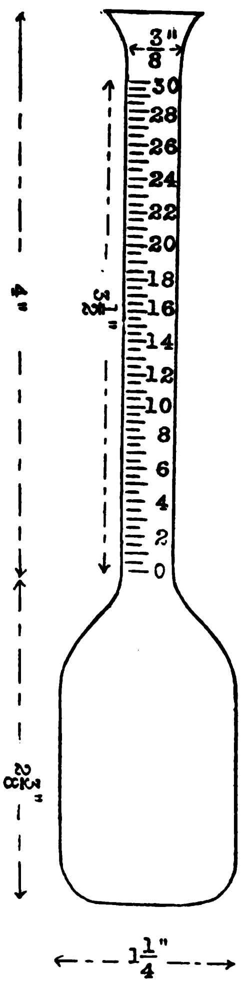

FIG. 19.—Design of a modified cream-test bottle.

entire graduation from 0 to 30 per cent. occupies a space of only two inches in length. This brings the lines of the scale very closely together so that the graduations which represent one-half per cent. of fat are not much farther apart than the

width of an ordinary pencil mark. With such test bottles it is almost impossible to read a test accurately to much less than one per cent. fat. This tendency of the manufacturers is a serious mistake, and when there are so many other difficulties in the way of testing cream accurately, they should rather make an effort to increase the length of the graduated scale than to diminish it.

Realizing the necessity of this I have had a cream-test bottle made of the dimensions shown in the diagram (fig. 19). This bottle is of the usual length of a milk-test bottle, but in order to give it a longer neck than cream-test bottles usually have, the size of the bulb of the bottle has been reduced so that it has a capacity of about 45 c. c. up to the zero mark of the scale instead of 55 c. c. which is the capacity of the bulb of the old cream-test bottles. This size of bottle, 40 to 45 c. c., is plenty large enough for mixing the cream and acid before whirling the test bottles in the centrifuge. The necks of many cream-test bottles on the market are only about 3 inches long, while those of the new cream bottle are at least 4 inches long; by making the diameter smaller the graduations of the neck are placed so far apart that it is easy to read one-fourth per cent. fat instead of one per cent. The scale representing one per cent. on the new cream-test bottle is as long as that of two per cent. in the old bottles. This elongating of the neck is a great help in reading the test accurately and to smaller fractions of one per cent. than one is able to read with the old cream-test bottle. The diagram shows the detail of construction and the dimensions of this new cream bottle.

INFLUENCE OF COLD CURING ON THE QUALITY OF CHEDDAR CHEESE.*

(Second Paper)

S. M. BABCOCK, H. L. RUSSELL, A. VIVIAN, AND U. S. BAER.

In the eighteenth annual report of this Station for 1901, the subject of cold curing of cheese was considered at length, and a considerable amount of data was presented which seemed to indicate that the quality of the product was sufficiently improved to warrant the introduction of this system into commercial practice. In this paper the results of four different series of experiments were presented. The first series was given in full but in series II, III and IV only a progress report could be made as the commercial life of the cheese had not at that time been completed. The general conclusions then drawn indicated that the flavor of cheese cured from the press at temperatures of 50° F. and below was uniformly mild and generally free from any undesirable characteristic. In no case, even where cheese were kept for a period of two years, were there any sharp flavors such as usually accompany an old cheese ripened under ordinary conditions. Such cheese broke down thoroughly, although more slowly than when cured at higher temperatures. The texture without exception was much improved and the body was firm and meaty.

The rate of ripening is necessarily retarded by these low temperatures, but this in a measure can be compensated for, by

*A more comprehensive treatment of the subject of cold-curing of cheese in its various aspects has been presented in Bulletin No. 94 of this Station, which was issued in August, 1902, under the following title: "Curing of cheddar cheese, with especial reference to cold-curing"

the use of increased quantities of rennet. A material increase in rennet is not permissible in ordinary practice, because high rennet cheese are prone to develop strong, undesirable flavors, a characteristic not observed in these cold-cured cheese, even where 9 ounces of rennet per 1,000 lbs. milk were used.

Not only was there a material improvement in the value of the product, as determined by flavor and texture, but the marked enhancement in keeping quality is also a commercial advantage. The use of these lower temperatures is further characterized by a diminished shrinkage in weight and a lessened development of mold, factors which are sufficiently important to carry a considerable share of the increased cost of cold curing.

This work has been continued during the present year and the results obtained are herewith presented, together with those of succeeding series.

SERIES II.

This series was started in May, 1900, at which time three lots of five cheese each were made with 3, 6, and 9 ozs. of rennet respectively. These cheese weighed approximately ten pounds apiece and one from each lot was cured at the following temperatures, 15°, 33°, 40°, 50°, and 60° F.

The data on this series were presented in the foregoing report up to a time when the cheese were 16½ months old. Those cured at 60° F. had at this time long since passed their commercial period, even those made with three ounces of rennet. Those kept at 50° F. had begun to deteriorate, the impairment in quality being more marked with those made with the larger quantities of rennet. The cheese cured at 40° F. when a year old were markedly superior to those kept at 60° F., at which time the two sets were cut up and shown at the meeting of the Wisconsin Dairymen's Association. When 16½ months old, all the remaining cheese of this series were cut in two, the cut faces of each piece being paraffined. These halves were subsequently stored at 40° F. and 60° F. respectively. At this time the cheese cured at 50° F. were on the decline, whereas

those kept at 33° F. were equal to, or above the market standard. Those which were kept in a freezing temperature (15° F.) cured slowly and were of inferior quality.

Although the cut surfaces of these cheese were paraffined, molds were not wholly excluded and the value of this experiment was vitiated in a number of cases. In all instances, however, where it was possible to make a fair comparison, the cheese subsequently kept at 40° F. for eight months longer was better than that stored at 60° F. This result applied to each lot made with varying quantities of rennet.

SERIES III.

This set was made by Mr. Baer at the University Creamery from normal milk on March 15, 1901. Normal amounts of rennet (3 ounces) were used and the cheese were kept from the press at 15°, 40°, and 60° F. At the writing of the last report, these cheese were seven months old and at that time, it was evident that the cheese cured at 60° F. had already begun to decline, while the others, particularly the 40° F. lot had steadily improved. At that date, the cheese in the freezing temperature (15° F.) were removed and subsequently stored at 40° F. while the other lots were kept at their previous temperatures. From this time on, the cheese at the higher temperature (60° F.) rapidly deteriorated and were putrid at fourteen months. The cheese kept continuously at 40° F. scored at fourteen months one point off on flavor and one on texture. Even the cheese which had been frozen for seven months and then stored at 40° F. for the remainder of the period were equal to standard product. The flavor was low but clean and the body and texture good.

TABLE I.— *Scores in Series III, cured at 15°, 40° and 60° F.*

Curing temperature.	Lab. No. of cheese.	Age in mos. when examined.	Commercial value (10 c. per lb. standard).	NUMERICAL SCORES. Flavor 45.	Texture 30.	DESCRIPTIVE SCORES. Flavor.	Texture.	Body.	Color.
15° F	19	2	9	40	27	Clean ..	Curdy ..	Close ...	Even.
		3	.....	.....	.....	.....	.....	.....	.....
		5	7	30	22	Musty ..	Curdy ..	Open ...	Wavy.
40° after 7 mos.		7	8	38	24	Fair ...	Curdy ..	Loose ..	Wavy.
		11	9.12	36	26	Fair	Curdy ..	Close ...	Even.
		14	10	42	28	Low, clean.	Good ...	Close. ..	Even.
40° F	17	2	8 62	41	25	Clean ..	Curdy. .	Close. ..	Even.
		3	9	38	27	Clean ..	Curdy ..	Close ...	Even.
		5	9	38	27	Clean ..	Curdy ..	Close ...	Even.
		7	10	41	29	Clean, low ...	Silky ...	Close ...	Even.
		11	9	35	22	Clean ..	Stiff	Close ..	Even.
		14	10	44	29	Good ..	Stiff	Close ...	Even.
60° F	18	2	8	34	23	Clean ..	Curdy ..	Close. ..	Even.
		3	10	40	28	Clean ..	Silky....	Close ...	Even.
		5	11	45	29	Clean, high ..	Silky....	Close ...	Even.
		7	9.75	40	27	Clean, sharp.	Slightly mealy.	Fairly close .	Even.
		11	....	....	....	Off	....	....	....
		14	....	....	....	Putrid .	....	....	....

SERIES IV.

This set was made on May 9, 1901, in a large vat, at the factory of H. J. Noyes, Muscoda, Wis. Normal milk was used and the ordinary quantity of rennet extract (3 ounces). The results of this experiment are entitled to more weight than any of the preceding series from the fact that the milk was of necessity the same in each cheese and the method of manufacture identical. Taking milk from other sections of the country and under other factory conditions than those which obtain in a single locality increases further the validity of the results. Immediately after removal from the press, these cheese were boxed and shipped to Madison for curing under the following temperature conditions:

The cheese in Lot I were stored directly from the press at 15°, 40°, 50°, and 60° F., respectively, two cheese being placed at each temperature. In Lot II they were kept for a preliminary period of fifteen days at 40° F. and then distributed as in Lot I. Lot III was similarly treated for a period of thirty

days and then handled as in Lot I. In all cases duplicate cheese were stored.

The results of these tests have been presented for a period of five months in full detail on p. 154 of the Eighteenth Report for last year. At that time the duplicate cheese in each set were separated, one being placed at 40° F. while the other was kept at 60° F. A comparison of these cheese will be shown in the following article in this Report (p. 165) entitled, "Influence of temperature on the development of flavor in cold-cured cheese," and therefore the detailed scoring is not repeated in this connection.

Without exception the cheese which were cured at 50° F. and below were of superior quality while those kept at 60° F. from the press were of good quality for only a short period of time. The cheese which were ripened for the first five months at 50° F. ranked within two or three points of perfect score, both as to texture and flavor. When these cheese were subsequently stored at 40°, they retained their good qualities to the end of the experiment which, in most cases, was one year. This emphasizes the manner in which these low temperatures conserve the quality of the product. The cheese kept at 40° F. developed a little more slowly but were of superior quality. Even when a year old they were adjudged worth twelve and one-half cents on a ten cent market standard. These cheese were examined by a number of disinterested experts and were pronounced of exceptionally good quality.

Professor Jas. Robertson, Commissioner of Agriculture of Canada, examined these cheese when they were six months old and at that time he selected the 40° series as the best and said that these were the ideal cheese wanted by the English market.

Even the cheese kept for five months at freezing temperatures (15° F.) and then subsequently cured at 40° were scored 44 flavor, 28 texture when a year old and rated at ten and one-half cents. In Lots II and III the cheese were kept for two and four weeks respectively at 40° and then stored for the balance of the five months period at 15°. They were removed to the 40° room and kept until a year old. These cheese ranged in value from 11 cents to a shilling a pound and were scored

in some cases perfect on both flavor and texture, a result somewhat remarkable for cheese which had been congealed for four months.

The final result in this series was wholly satisfactory and indicated beyond doubt that these lower temperatures produce a product that is superior to that cured in the ordinary way. The value of this result is still further enhanced when it is remembered that these cheese were identical as to milk, method of manufacture, etc., and that all differences here observed were wholly due to the curing treatment.

SERIES V.

The foregoing series were supplemented with another lot of cheese which were made under uniform conditions by Mr. Baer at Muscoda, Wis., on October 26, 1901. These cheese were made with six and nine ounces of rennet and were cured at 32° to 35°, 40° and 60° F.

The results of these tests are shown in Table II, page 156.

The results attained in this series confirm those previously observed, in that the quality of the cheese ripened at 40° and 32° was improved over that held at 60° F. The cheese kept at the lower temperature also retained their good quality for a longer period than that held at 60° F. The use of increased quantities of rennet facilitated the ripening of the cheese and it was noticeable that the texture of the product was also favorably influenced, being of a rich buttery nature.

A considerable number of duplicate cheese were made in this lot and when these were in their prime they were disposed of on the local and Chicago markets. These were readily disposed of at prices from 2 to 2½ cents above the market price. The opinion of the grocery men who handled these goods was that the cheese were of the finest quality and were eagerly sought for by the retail trade.

The general results obtained from these five series of experiments, covering a wide range in temperature and other conditions, lead us to believe that the benefits derived from the use of this method of curing cheese at lower temperatures than heretofore employed are of sufficient importance to warrant

the introduction of this method into general practice where it is possible to handle sufficient quantities of cheese to economically employ refrigeration.

TABLE II.— *Scores of cheese in series V.*

Curing temperature.	Age (in mos.) when examined.	Commercial value 10c. per lb. standard.	Numerical Scores.		Descriptive Scores.			
			Flavor 45.	Texture 30.	Flavor.	Texture.	Body.	Color.
		Cheese made with 6 ounces of rennet.						
32° F.	1	8	35	22	Clean ..	Curdy ..	Close...	Even.
	3½	8.75	37	24	Clean ..	Curdy ..	Close...	Even.
	8	12.5	45	30	Perfect.	Perfect.	Close...	Even.
40° F.	1	8.25	35	23	Clean ..	Curdy ..	Close...	Even.
	3½	8.75	37	26	Clean ..	Curdy ..	Close...	Even.
	6½	12.5	45	30	Perfect.	Perfect.	Close...	Even.
	8	12	45	30	Perfect	Perfect.	Close...	Even.
60° F.	½	8	32	24	Low. ..	Smooth.	Close...	Even.
	1	10	40	28	Clean ..	Silky ...	Close...	Even.
	2	10.25	43.5	29	Clean ..	Silky ...	Close...	Even.
	3½	10	40	30	Clean ..	Silky ...	Close...	Even.
	6½	8.75	38	23	Slightly off....	Fair ...	Close...	Even.
	8	5.5	25	25	Off	Crumbly	Close...	Even.
		Cheese made with 9 ounces of rennet.						
32° F.	1	8	35	22	Clean ..	Curdy ..	Close...	Even.
	3½	9	38	25	Low....	Curdy ..	Close...	Even.
	8	11	41½	29½	Clean ..	Smooth.	Close...	Even.
40° F.	1	8.5	35	24	Low ...	Curdy ..	Open ...	Even.
	3½	9	38	28	Clean ..	Curdy ..	Close...	Even.
	6½	12½	45	30	Perfect.	Perfect	Close...	Even.
	8	12	45	30	Perfect.	Perfect.	Close...	Even.
60° F.	½	8.5	35	23½	Low....	Smooth	Open ...	Even.
	1	10	40	28	Clean ..	Smooth	Open ...	Even.
	2	10	42	29	Clean ..	Smooth.	Close...	Even.
	3½	10	40	30	Clean ..	Perfect.	Close...	Even.
	6½	8.5	38	25	Slightly off....	Weak...	Close...	Even.
	8	5.5	25	21	Off	Crumbly	Close...	Even.

The following summaries as to flavor, texture, body and color are herewith presented.

FLAVOR.

The lower temperatures employed, 50° and below, have uniformly given a very mild, clean flavor which does not become sharp with age, as is the case in all the cheese cured at 60° F. Almost without exception these cheese have not acquired any bitter or otherwise undesirable flavor, except in some cases where the milk was imperfect. This result stands in striking contrast with the universally accepted opinion which has heretofore been held as to the influence which low temperatures exert on the flavor of cheese. The cheese kept continuously at 15° do not produce a good flavor, but storage, even under these adverse conditions, does not necessarily harm the flavor if such cheese are subsequently held at a temperature higher than freezing. The best flavors were noted in the case of cheese kept from freezing point to 40° F. In some instances, however, excellent cheese were obtained at 50° F. The marked difference in flavor between these cold-cured goods and those ripened at higher temperatures shows the influence which heat has on the production of those characteristic products to which the peculiar flavor of cheddar cheese is due.

There can no longer be any question but that these lower temperatures can be used from the press, not only with safety, but with great advantage, as they produce a cheese which is mild and palatable, and suits the general market demand much better than the sharp flavored product obtained under ordinary curing conditions.

TEXTURE.

With reference to texture these cold-cured cheese were frequently perfect, scoring 30 out of a possible 30. Practically without exception, the cheese cured from 33° to 40° were of better texture than those ripened at 60°. During the early history of the cheese, the texture has a tendency toward mealiness and is sometimes curdy, but this is simply because the

product is uncured. With increasing age the texture improves, becoming smooth, waxy and silky.

The cheese cured at 15° did not acquire this fine texture while at these freezing temperatures, but when placed at 40° F. after sixteen months old, improved.

Those kept at the higher curing temperatures (60°) were generally of fair to good texture for a short time, but with increasing age they became "short" and "salvy" even when comparatively a few months old (six to eight).

BODY AND COLOR.

The body and color of the cheese cured from 33° to 40° was very satisfactory and much better than that cured at 60° F. When the cold-cured cheese were cut they were perfectly solid while the 60° cheese were more or less open and frequently bleached. With increasing age this undesirable condition became worse in the 60° product, while the cheese cured at lower temperatures generally remained close and even throughout. The difference in body and color noticeable at 40° and 60° with cheese made with normal amounts of rennet was greatly intensified when a larger quantity of rennet was used.

The holes found in these cheese cured at 60° F. are irregular, ragged and variable in size. They are easily differentiated from the round, smooth, Swiss hole which opening is due to distention caused by the accumulation of gas. The irregular holes above referred to are always located between the curd particles and seem to be formed by the contraction of these particles which is undoubtedly produced through the continued action of the rennet. The bleaching of the curd is directly related to the formation of these irregular openings. For a varying distance around these openings, the curd loses its color with age and the mottled or wavy condition of the cheese in the earlier phases of its ripening passes into a badly bleached state as the curing progresses.

COMMERCIAL VALUE.

Throughout these experiments the cheese have been judged on the basis of a ten cent market. In most of these series the control cheese cured at 60° F. scored up to the market standard in a few months but soon deteriorated in value. The cold-cured cheese reached their prime necessarily later, but in many cases were adjudged as worth from ½ to 2 cents per pound above the standard. This condition was maintained for relatively long periods of time, thus enhancing their value, by lengthening the "commercial life" of the product. The cheese kept in a frozen condition for a major portion of a year generally were off in value, but it is noteworthy that when these cheese were placed at 40° for a few months they often improved.

CONFIRMATORY DATA FROM OTHER SOURCES.

These experiments on the cold-curing of cheese were begun by us in February, 1899. The first public presentation of the data secured was made at the meeting of the Wisconsin Cheesemakers' Association in February, 1901.

In April of that year, Professor Dean of the Ontario Agricultural College began a similar line of experiments the results of which he gave at the meeting of the Dairymen's Association of Western Ontario in January, 1902.[1] His experiments were continued from April to November. Cheese were taken directly from the hoops and placed in ice cold-storage at about 40° F. Other cheese were given a preliminary cure at 65° F. for periods of one, two and three weeks respectively, and then cold-cured at 40°. A control cheese was kept continuously at 65° F. Professor Dean reports the cold-cured cheese as having reached in three or four months about the same condition of ripeness as a four to six weeks' ordinarily cured product. These cheese were examined by other experts who gave the product cold-cured directly from the press a higher value in most cases than those which received

[1]Report of the Dairymen's Associations of the Province of Ontario, 1901, p. 95.

the short preliminary cure. The cheese cured at 65° went off flavor before the other cheese had reached their prime.

All of the experts concerned were much surprised to find the cold-cured cheese free from bitter flavors and possessing such a superior texture. Professor Dean's experiments have not yet been completed, but he is prepared at the present time to recommend that summer-made cheese be put into cold storage directly from the press.

It should also be noted that the Canadian Government has already inaugurated an extended system of cold-curing plants of this character in which the product is cured directly from the press. The results attained under these conditions have not yet been published.

Last year a number of cheese dealers in this state followed this plan of curing and bought a considerable amount of cheese for cold-curing directly from the press. The results attained under these commercial conditions were wholly satisfactory and convinced even the most skeptical that the process could be used with advantage.

This year, a much larger amount of cheese is being handled in that way. During the summer the La Crosse Cheese & Butter Co. of La Crosse, Wis., have placed several hundred packages per week in their cold storage rooms at about 45°. A number of the wholesale dealers of Chicago are likewise cold-curing a large portion of the entire product that they are handling this year.

The custom of placing cheese in cold storage for holding has been followed for some time. At first this was only done with ripened cheese, but the tendency has been to shorten up the period of curing at the factory and put the cheese into storage earlier. This has been done not so much to cure the cheese in cold storage as to hold the partially cured cheese with but little subsequent change. Cheese-buyers have uniformly feared to place cheese under these conditions directly from the press, because it has been a generally accepted idea that such a course would inevitably result in the production of a bitter flavor. Early cold storaging differs from the process of cold-curing here proposed in that the development of gassy cheese or "hot"

flavors is likely to occur where a preliminary higher curing temperature is maintained even for a short time before the product is placed in cold storage.

UNIFORMITY OF PRODUCT.

An advantage of no mean consequence is the increased uniformity in the character of cold-cured cheese. At the present time most factories suffer considerable loss through cheese rejected on account of their inferior quality. Such losses are in part due to the use of tainted milks and variation in manufacturing details, but in a large measure, the losses may be ascribed to variation in curing conditions not now properly controlled. Of these, temperature is by far the most important. With cheese cured at lower temperatures, the effect of these factors is much minimized, not only with reference to those inherent to the curing but also those involved in the manufacture. The result is that the quality of the cheese is more uniform and on this account brings a somewhat higher price or at least is much more sought after by the buyer. To the cheese dealer, this is a factor of considerable importance.

KEEPING QUALITY OF COLD-CURED CHEESE.

In discussing the relative merits of cold-cured vs. normal-cured cheese as to keeping quality, we will consider first, the cheese made with normal amounts of rennet, for the use of high rennet is practically excluded in cheese cured at usual temperatures. The cheese kept at 60° F. in most cases were at their best within a few months. Generally they acquired a sharp flavor, even at this temperature, if they were more than six or eight months old. After reaching their optimum condition, they rapidly declined, although of course this deterioration would have been retarded if such cheese had been placed in cold storage when they were in the best condition, a method which is now generally practiced by dealers.

With the cheese kept at the lower temperatures, 50°, 40°, and 33° F., the highest and best flavors were of course more slowly developed than in the higher cured series, but the length

of time during which they were at their best was maintained for a much longer period, and in many cases, cheese a year and a half old were still in prime condition as to both flavor and texture. This gives a keeping quality from two to four times as great as would be secured in the best curing rooms as they now exist. Naturally the 50° temperature does not hold the cheese as well as the lower limits.

Where six or nine ounces of rennet were used and the cheese cured at 50° F. and below, the product was much improved over that kept at 60°. The use of increased quantities of rennet hastens the ripening, and likewise curtails the keeping quality somewhat when kept at cold-curing temperatures, but even under these conditions the keeping quality is much better than where three ounces of rennet were used and the cheese ripened at 60° F.

So far as these experiments can determine the question, the use of high rennet is not only permissible but in our judgment advisable, although such cheese should be kept at low temperatures, say 33 to 40° or possibly 45° F.

LOSSES IN COLD-CURING.

The loss in weight which cheese undergoes in curing due to evaporation of water is a question of importance to the manufacturer. At high curing temperatures this loss reaches its maximum and of necessity is diminished as the curing temperature is lowered, providing the relative humidity remains the same.

In our experiments we were unable to secure much data on the question of loss at the different curing temperatures as the cheese were of necessity plugged at frequent intervals, but in Series V a number of duplicate cheese were made which were not bored and on these the following observations were made:

Twenty-three cheese (13 30-lb. flats and 10 20-lb. daisies) were cured at 40° F. for a period of eight months. The loss in weight for this entire period was six per cent. for the thirty-pound cheese and six and one-half per cent. for the twenty-pound cheese. Three (30-lb. flats) cheese were kept at 60°

for the same period in which the loss was twelve and one-half per cent., or double what occurred in the cold-cured cheese.

This would show that the saving was about one-half in the cold-cured cheese over what would occur if the cheese were kept at the higher temperatures. But it must be remembered that in comparing relative losses at high and low temperatures, the time during which the cheese is normally kept under the two conditions is different, the high temperature-cured cheese being sold to the cheese-dealer or consumer much earlier than would be possible in the cold-cured product. If such cheese, however, are kept in cold storage after their removal from the curing-room, the loss from this time is nearly as great as in the cheese cured continuously at low temperatures.

Comparing then the inevitable losses occurring in cold-cured cheese with those ripened at the usual temperatures now employed, we may say with certainty that the lengthened curing period will not result in an increased loss over that which obtains by present methods. With the smaller types of cheese, and at the fluctuating temperatures of ordinary curing rooms, there will doubtless be a saving in weight.

INCREASED PERIOD REQUIRED FOR CURING.

Under cold-curing conditions it manifestly follows that the period during which the cheese is ripened must be considerably longer than where a higher ripening temperature is employed. In our experiments the cold-cured cheese have reached their prime in about six to eight months. The length of this period is in part controlled by the amount of rennet used. (See p. 174, this report, for article entitled, Influence of Varying Quantities of Rennet on Cold-Cured Cheese.)

This is considerably longer than the present practice, and therefore involves somewhat greater expense for carrying charges. We confidently believe from our own experience and from data gathered this season from dealers that are handling their product satisfactorily in this way, that this increased cost of production is much more than met by the improvement in quality and diminution in losses.

SUMMARY.

The results obtained in the experimental tests which have been conducted since the publication of the last report confirm those stated in the Annual Report for 1901, to-wit:

1) That cheese can be cured with safety and advantage when placed directly from the press at temperatures ranging from 35° to 50° F.

2) At these temperatures the flavor is mild even when the cheese acquires considerable age, the texture smooth, waxy and silky, the body solid and the color even. In all respects the product at these lower temperatures is improved over that ripened at 60° F., the temperature that has heretofore been considered ideal for cheddar ripening.

3) The rate of curing is dependent upon the temperature employed, being more rapid at the higher temperatures used. The quality of the product is, however, quite similar in cheese cured through a range of 10–15° from 50° F. downward.

4) In comparison with cheese made under identical conditions but cured at 60° F., the commercial value of the cold-cured product was almost without exception superior.

5) Not only is the cold-cured cheese of better quality itself, but it is of much more uniform grade, and possesses a very much better keeping quality than that cured at 60° F. and above.

6) From our own and others' experiments it appears that the improvement in quality and diminution in losses more than compensates for the increased carrying charges that this system of cheese-curing involves.

INFLUENCE OF TEMPERATURES APPROXIMATING 60° F. ON THE DEVELOPMENT OF FLAVOR IN COLD-CURED CHEESE

S. M. BABCOCK, H. L. RUSSELL, A. VIVIAN, AND U. S. BAER.

A characteristic that has been prominent in our experiments in all of the cheese which have been cured from the press at temperatures below those normally employed is that the same possess a relatively mild but clean flavor. This so characterizes the cold-cured cheese that it shows that temperature exerts a strong influence on the intensity and quality of the flavor. Practical experience is in accord with this view, and the baneful effects of high temperatures on flavor development are thoroughly recognized.

While the market desires a well broken-down cheese, it wants at the same time, a relatively mild flavor, a condition which it is impossible to obtain where cheese are ripened at temperatures usually employed. The use of the cold-curing system permits of the production of a perfect texture with the development of a relatively low flavor. These cheese never acquire, even when two years old or more, the sharp, biting flavor that always accompanies an old cheese ripened at higher temperatures (60° and above). In fact, the flavor is often too mild to suit the palate of many cheese consumers.

Recognizing the relation that temperature exerts on the production of these characteristic high flavors in cheese, we have conducted a large number of experiments with cold-cured cheese to determine whether subsequent exposure to higher temperatures would intensify the flavor of these thoroughly ripened cheese, without producing the disagreeably sharp, biting flavors that always are associated with the old cheddar product.

Below are presented the results of a series of examinations extending throughout a period of one year. These cheese (20 in number) were made by Mr. Baer at Muscoda in May, 1901 (Series IV of foregoing article), from a single vat of milk with usual quantities of rennet. They were immediately shipped to cold storage rooms and handled as follows:

They were divided into three lots, one lot of which was placed immediately at the respective temperatures, 15°, 40°, and 50° F., two cheese being distributed at each temperature; the second lot was held for 15 days at 40° F., and then distributed as above; the third lot was kept at 40° F. for 30 days and subsequently distributed. After the cheese had been kept at the respective ripening temperatures (15°, 40°, and 50°) for a period of five months, the two cheese in each lot at the different temperatures were divided and one of them stored at 60° F., while the other was placed at 40° F. Under these conditions, a variation in the intensity or character of the flavor must of necessity be attributed to the direct or indirect influence of the temperature employed.

Table I gives the commercial rating and numerical score on flavor and texture.

TABLE I.

LOT I.

Curing temperatures employed.

Age in months.	15° F.			40° F.			50° F.			60° F.		
	Cts.	F.	T.	Cts.	F.	T.	Cts.	F.	T.	Cts.	F.	T.
Cheese kept 5 months at 15° F. directly from the press, then divided, part being placed at 40° F., the remainder at 60° F.												
1	7.0	35	22									
3	6.5	30	20									
5	6 0	30	22									
6										10.0	43	29
7										10.0		
9				9 5	40	27				10.25		
12				10.5	44	28						
Cheese kept 5 months at 40° F., then divided, part being placed at 60° F., the remainder at 40° F.												
1				8.0	34	24						
3				8.0	35	24						
5				10.0	42.5	28.5						
6										10.25	43	29.5
7										10 25		
9				10	42.5	29						
12												
Cheese kept 5 months at 50° F., then divided part being placed at 40° F., the remainder at 60° F.												
1							8.5	37	25			
3							8.5	38	26			
5							10.25	43.5	30			
6										10	43	27
7										10		
9				10.5	43.3	29.5				10.5		
12												

LOT II.

Curing temperatures employed.

Age in months.	15° F.			40° F.			50° F.			60° F.		
	Cts.	F.	T.	Cts.	F.	T.	Cts	F.	T.	Cts.	F.	T.
Cheese kept 15 days at 40° F., then cured at 15° F. until five months old, then divided between 40° and 60° F.												
1	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
3	7	32	25	.....	.....	.....	.....	.....	.....	.....	.....	.....
5	7.5	35	20	.....	.....	.....	.....	.....	.....	.....	.....	.....
6	.....	.....	.....	.....	.....	.....	.....	.....	.....	8.0	36	24
7	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
9	.....	.....	.....	11.0	45	30	.....	.....	.....	.....	.....	.....
12	.....	.....	.....	11.0	45	28	.....	.....	.....	.....	.....	.....
Cheese cured at 40° F. until 5 months old, then divided, part being placed at 60° F., the remainder left at 40° F.												
1	.....	.....	.....	8 5	36	26	.....	.....	.....	.....	.....	.....
3	.....	.....	.....	9.5	38	28	.....	.....	.....	.....	.....	.....
5	.....	.....	.....	10 1	43	29	.....	.....	.....	.....	.....	.....
6	.....	.....	.....	.....	.....	.....	.....	.....	.....	10.5	44 5	29.5
7	.....	.....	.....	.....	.....	.....	.....	.....	.....	9.	.....	.....
9	.....	.....	.....	10.75	44	30	.....	.....	.....	.....	.....	.....
12	.....	.....	.....	12.5	45	30	.....	.....	.....	.....	.....	.....
Cheese kept 15 days at 40° F., then cured at 50° F. until 5 months old, then divided between 40° and 60° F.												
1	.....	.....	.....	.....	.....	.....	8 5	38	25	.....	.....	.....
3	.....	.....	.....	.....	.....	.....	9 5	40	27	.....	.....	.....
5	.....	.....	.....	.....	.....	.....	10 0	42	25	.....	.....	.....
6	.....	.....	.....	.....	.....	.....	.....	.....	.....	10	42	29
7	.....	.....	.....	.....	.....	.....	.....	.....	.....	9.75	.....	.....
9	.....	.....	.....	11	45	30	.....	.....	.....	9	.....	.....
12	.....	.....	.....	12.5	45	30	.....	.....	.....	....	.....	.....

LOT III.

Curing temperature employed.

Age in months.	15° F.			40° F.			50° F.			60° F.		
	Cts.	F.	T.	Cts.	F.	T.	Cts.	F.	T.	Cts.	F.	T.
Cheese kept 30 days at 40° F., then cured at 15° F. until 5 months old, then divided between 40° and 60° F.												
1				9 25	40	2[illegible]						
3	7 25	32	24									
5	8.75	38	26									
6										9.0	38	27
7												
9				10.0	42	27						
12				12.5	45	30						
Cheese kept at 40° F. until 5 months old, then divided, part placed at 60° F., the remainder at 40° F.												
1				9 25	39	27 5						
3				10.25	42	28.5						
5				10 25	43 5	29.5						
6										10.25	43.5	29.5
7										10.0		
9				10.75	44	30						
12				9.0								
Cheese kept 30 days at 40° F., then cured at 50° F. until 5 months old, then divided between 40° and 60° F.												
1				9 0	38	28						
3							10 0	42	28			
5							10.5	44	30			
6										9.25	37	26
7										9.		
9				10	42	28						
12				12.5	43	30						

DISCUSSION OF RESULTS.

1. *As affecting intensity of flavor.*—The above results indicate that at the expiration of five months the cheese cured at 15°, 40°, and in some cases at 50° F., were low in flavor but without exception clean. At this date one of each pair of cheese was placed at 60° F. and the other at 40° F. Unfortunately simultaneous records were not secured on these two lots, owing to the fact that the cold storage goods were stored in cold storage rooms at Waterloo, some distance from Madison, and hence could not be so readily inspected. Reference to the table shows that the flavor of the cheese placed at the higher temperature (60° F.) was materially enhanced within one month. This is more evident from a consideration of the descriptive score which distinguishes the quality of the flavor than from the numerical judgment. The extent of this change can be modified by the period of exposure and undoubtedly in many cases a shorter exposure would suffice.

The change in flavor was in the great majority of cases one of degree and not of quality. It was toward the typical cheese flavor found in the most desirable cheddar cheese. It did not partake of the sharp biting tang that is so frequently to be observed in cheese ripened at higher temperatures.

It should be noted further that if the cheese are left for a considerable period of time at these higher temperatures they soon deteriorate in flavor. It is, however, possible to intensify this flavor development to a desirable point and then return the cheese to a lower temperature, when further development is immediately checked and the acquired flavor maintained for a considerable period of time. This condition is one of considerable economic importance as it permits of the development of a range in intensity of flavor that will suit all phases of the market and by subsequent refrigeration enables the desired condition to be maintained for a much longer period than usual.

At 40° F. the flavor was perfectly clean and mild but not so marked as at 60°, a condition which is perhaps of greater value for the market, which is inclined to prefer a mild as opposed to a sharp flavor.

2. As affecting keeping quality.—A comparison of the partially ripened cheese which were kept after five months in temperature rooms at 40° and 60° F., indicate the effect which temperature exerts on the keeping quality of the ripening product. It was always the case that the cheese stored at 60° developed flavor more rapidly than those kept at 40° F., but the period of time during which they retained a desirable flavor and which necessarily marks the commercial life of the product was much curtailed at 60° from what it was at 40° F.

At 40° F., many of these cheese scored perfect when twelve months old, while those kept at 60° had long since passed their prime.

3. Preliminary ripening at higher temperatures.—The original plan of this experiment was to expose certain lots of these cheese to a short preliminary ripening at 60° F. before they were kept at lower temperatures for the main ripening period. It was intended by this to test the effect of prevailing commercial conditions in which it is difficult to secure sufficiently low temperatures without recourse to artificial refrigeration. Unfortunately the rooms which we hoped to be able to hold at 60° F. were then unprovided with heat, and the observed temperature was materially lower (about 40° F.). The diurnal fluctuation was practically nothing, as the curing rooms were well insulated and below ground.

Under these conditions the cheese were not ripened as far as intended, but reference to Table I shows that the cheese in Lots II and III (kept at 40° F. for fifteen and thirty days previous to main curing period) had a more developed flavor than those in Lot I, which were distributed to the various curing rooms immediately after removal from the press. This is more evident at the higher temperatures but is observable throughout.

Without question the use of a higher temperature would have accelerated this preliminary ripening, and it is a most important question to know how high a temperature and for how long a period it can be maintained without seriously impairing the quality of the cheese. Experiments designed to answer specifically this question are now in progress. The practical

bearing of this problem on factory practice is apparent, for in many cases, immediate refrigeration of the cheese is impracticable and it would be of inestimable importance in the development of consolidated cold-curing stations if it is possible to hold the cheese without injury at the factory for a few days.

4. Dangers involved.—The chief danger attendant on the preliminary treatment at higher temperatures lies in the handling of cheese made from tainted milks where gaseous fermentations are prone to occur. Such cheese invariably "huff" when kept even for a few days at elevated temperatures. When immediately placed at low temperatures this fermentation is repressed and the consequent bad flavors are not so likely to be produced. Moreover, if such cheese are ripened at these low temperatures the liability of subsequent huffing is likewise greatly diminished. It must not be considered, however, that such milks will ever produce, even under this system, as good cheese as first class milk.

SUMMARY.

The conclusions drawn from the preceding series have been confirmed in a number of cases where cheese has been made for other purposes.

1. The mild flavors which characterize cold-cured cheese may be intensified by subsequent exposure to somewhat higher temperatures (approximately 60° F.). The flavor so produced does not partake of the sharp tang usually found in old cheese cured at high temperatures. Care must be taken not to have this temperature too high nor maintained too long, as in a partially cured cheese this subsequent enhancement in flavor rapidly occurs.

2. In order to hold the desirable flavors for the longest possible time, and so lengthen the commercial "life" of the cheese, the same should be returned to lower temperatures for storage as soon as the desired flavor is reached. Under such conditions further development is stopped and such cheese may be held unimpaired for many months.

3. With cheese made from first class milks the rate of ripening can be hastened by a brief preliminary exposure to a higher

temperature (not much exceeding 60° F.), but the improvement in the product both as to nature and keeping quality of same when cured at low temperatures makes it preferable to employ low temperatures for the bulk of the curing. Where consolidated cold-curing stations are established, transportation of the green product from the factories requires a brief period (a few days) during which time no damage is likely to occur. With imperfect milks there is always danger in curing even for a brief period at temperatures normally employed. The cold-curing system is more likely to give favorable results with such milks.

INFLUENCE OF VARYING QUANTITIES OF RENNET ON COLD-CURED CHEESE.

S. M. BABCOCK, H. L. RUSSELL, A. VIVIAN, AND U. S. BAER.

It is a common belief among practical cheesemakers that an increase in amount of rennet used hastens the rate of ripening of cheese. In the 17th Annual Report of this Station for 1900 the influence of varying quantities of rennet was made the subject of a thorough investigation. The results of this study showed that additional quantities of extract do increase the rate of ripening and that this increase was attributable to the action of the pepsin contained in the rennet extract. The soluble products formed are confined to the higher decomposition products of proteids, albumoses and peptones precipitated by tannin.

Where cheese is cured at ordinary curing temperatures an increased quantity of rennet shows not only a more rapid breaking down of the casein, but also affects profoundly the character of the flavor. High rennet cheese cured at 60° F. and above are invariably short lived and soon acquire a strong, sharp, rank flavor that destroys their commercial value. For this reason large quantities of rennet are used in practice only where a quick-curing cheese is wanted and one which is to be consumed in a short time.

HIGH RENNET IN COLD-CURED CHEESE.

In our experiments on cold-cured cheese, we have taken advantage of the property which rennet possesses in hastening the ripening of this product and have made a series of experiments to determine the influence which increased quantities of

rennet would exert on the character of cheese ripened under these conditions.

Cheese have been made with the normal amount of rennet (3 oz. per 1,000 lbs. milk), also with double and treble this amount. These cheese were cured from the press at temperatures ranging from 15° to 60° F. Several series of cheese have been made and studied in this way. The following history gives the details of these experiments:

FIRST EXPERIMENTS (CHEESE SERIES III).

The cheese in this series were made in May, 1900, and the detailed history of the same was reported in the 18th Annual Report (p. 138). A chemical study of the same was made for a period of fourteen and a half months and the conclusions then observed confirmed in every detail those previously referred to.

Flavor.—With reference to flavor, it was found that the cheese made with normal amounts of rennet and cured at 60° F., were better than those made with larger quantities of rennet; on the other hand, the use of higher rennet at lower temperatures gave excellent results. Not only did the high rennet cheese at 50° and below cure more rapidly than the 3-ounce rennet series, but the nature of the flavor was much improved. These cheese scored from 43 to 45 in flavor (45 perfect) and were ranked as worth 10.5 to 11 cents on a 10-cent market. There was none of the sharp, rank flavor present which characterizes the use of high rennet at higher temperatures.

Texture.—At the high temperature (60°) an increase in amount of rennet markedly affected the character of the texture, making it pasty or sticky. At the lower temperatures even with nine ounces of rennet, the texture was waxy or silky, except at 15° F., where a curdy texture was retained for a long time.

Body.—The effect of varying amounts of rennet on the body of cheese was very evident, as is seen in Fig. 20. At all temperatures an increase in rennet has a tendency to make a more open body. At the high temperature used (60° F.), this becomes very pronounced, the cheese with nine ounces being

very loose and spongy. At the lower temperatures this effect is diminished, the cheese made with nine ounces and cured at 40° F. having a less open body than the normal rennet (three ounces) at 60° F.

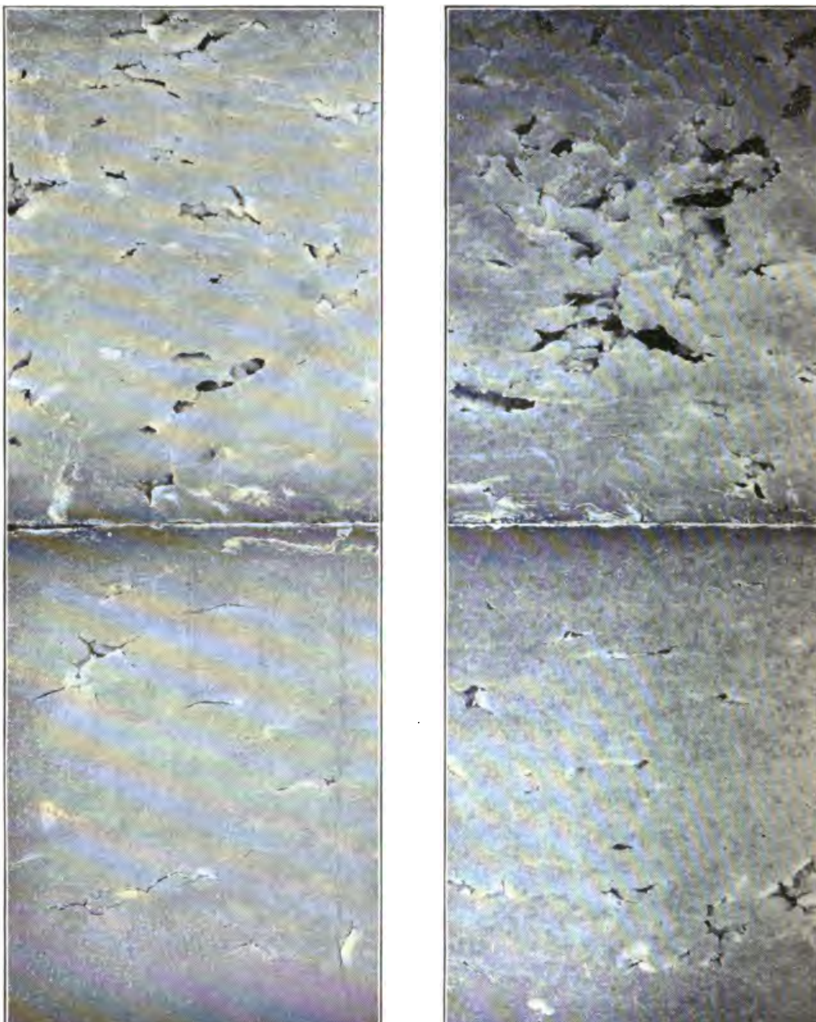

FIG. 20.—Influence of varying amount of rennet extract upon the texture of cheddar cheese. Cheese in right hand figure made with 9 ozs. rennet; in left hand figure, 3 ozs. per 1,000 lbs. milk. Upper cheese cured at 60° F.; lower at 40° F. Note more open body in high rennet cheese.

This increase in rennet results in the production of a loose open body and raises the question as to how this effect is produced. A study of the nature of the holes noted in an open bodied cheese will throw light on the question. Openings or holes in cheese are usually of two classes. One due to the formation of gas which usually results in the production of a more or less rounded opening with quite smooth walls as is found in a typical Swiss cheese or in a badly huffed Cheddar cheese The other type is the rough ragged irregular opening which is generally found between the curd particles. These vary much in size and shape and may be designated as "mechanical" holes. Their origin is evidently not due to the production of gas but to an imperfect matting or closure of the curd. Such holes are particularly pronounced in a sweet curd cheese when taken from the press. They are, however, very likely to be modified by subsequent production of gas which may distend them and so alter their general form.

The openings to be noted in these high rennet cheese partake of the nature of these mechanical holes, although they are probably modified by the operation of a different set of forces. These openings start between the curd particles as in the true mechanical holes but they increase in size and irregularity through the shrinkage of the curd, and are in no way related to the action of gas as is shown by the fact that such cheese do not huff. The cause of this continued shrinkage of the curd mass is not due so much to the drying out of the cheese as it is to the compacting of the individual curd particles. This continued action is a function of rennet which causes the casein to contract in volume, this expelling the whey, a phenomenon easily observed in the cheese vat. Just as an increase in amount of rennet used in the vat reduces the curd mass in size, so in the cheese the action of rennet is continued, further causing a shrinkage in the curd which inevitably results in the enlargement of these mechanical holes and the formation of others. This hypothesis is confirmed by the slightly depressed face generally to be noted in high rennet cheese, cured at relatively high temperatures.

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Color.—The use of high rennet has a tendency to produce a mottled appearance in the cheese, which is intensified by the action of high temperature. At low temperatures (50° or below) the color remained uniform for a long period with all quantities of rennet. As cheese increases in age, there is a tendency for the color to become wavy, but in the cold-cured product this rarely becomes pronounced enough to injure the product.

The bleaching of cheese made with high rennet and cured at 60° F. first makes its appearance in connection with the ragged holes found at these temperatures. Surrounding these openings and extending into the curd mass for a varying distance, there is often to be noted a bleached area in which the color of a colored cheese is "cut." A mottling effect generally precedes the production of a loose as opposed to a close body, which becomes more pronounced as the body changes with age.

RESULTS OF FIRST EXPERIMENTS (SERIES II).

These experiments show that high rennet (9 ozs.) cannot be used with safety in cheese cured at 60° F. but if such cheese are cured at lower temperatures an increased quantity of rennet does not injure the product while at the same time it facilitates the curing. At 50° F. or under, the flavor of 9 ounce rennet cheese was of superior quality even when a year old. The texture of such cheese was perfect and the body and color excellent. So far as these experiments indicate the use of increased rennet is not only permissible but desirable if the cheese are cured at low temperatures (50° F. or below).

SECOND EXPERIMENTS (CHEESE SERIES V).

A second series of cheese were made by Mr. Baer in October, 1901, at Noyes' factory at Muscoda. These were made with six and nine ounces of rennet and ripened directly from the press at 32°, 40° and 60° F. The full detailed history of this lot of cheese has been presented as series V in foregoing article entitled, Influence of Cold-Curing on the Quality of Cheddar Cheese, page 150, this report, and consequently need not be given in full in this connection.

The results of these tests show that at 32° and 40° F. even nine ounces of rennet per 1,000 lbs. could be used with safety. When these cheese were eight months old they were adjudged perfect (45 flavor, 30 texture) and were considered worth from one to two cents above the standard market price.

However, the cheese made with six ounces of rennet were also quite as good and ripened up nearly as rapidly. They also had a tendency to hold the mild flavor better than the nine ounce goods and it is our judgment that the use of six ounces under cold-curing conditions is perhaps preferable to a higher amount. These experiments thoroughly demonstrate that larger than normal quantities can be used with advantage, in that they give a more buttery and softer texture and also hasten the ripening course.

CONDITIONS AFFECTING THE DEVELOPMENT OF WHITE SPECKS IN COLD-CURED CHEESE.

S. M. BABCOCK, H. L. RUSSELL, A. VIVIAN, AND U. S. BAER.

In the work reported last year on the cold-curing of cheese, the observation was made that almost invariably when cheese were cured at 50° F. or below, small white specks were found more or less uniformly distributed throughout the cheese. The nature of the specks is not as yet known but this year a series of experiments have been undertaken with the view of determining the conditions under which they appear. The formation of these white specks does not apparently affect the flavor or texture in any way, and from a commercial point of view are not of much significance as they are quite obscure. When the cold storage stock was examined in the rooms, often they were inconspicuous, but upon warming the same they became more evident.

So far as we know, the observation previously recorded is the first reference to this matter, but later examinations made by Mr. Baer on cold storage stock held in various portions of the state show that these white specks were present in all such goods, although they had not been noticed previously by the dealers. The following series of experiments were conducted to ascertain if possible the conditions that governed the formation of these white specks.

Cheese were made with varying quantities of rennet, with and without salt and color, and cured at 40° and 60° F. Previous observations had shown that specks appeared in the 40° cheese but not in the 60° F.

I. *Effect of temperature.*—Twelve cheese were made under varying conditions as to salt, rennet, and color but were divided

into two lots of six each which were cured respectively at 40° and 60° F.

In the case of those kept at 60° specks were not observed in any case except in two instances where no salt was used. In these they were few, and located near the rind but even these disappeared as the cheese grew older.

In the case of the 40° cheese the appearance of white specks was the usual rule. Where the cheese were unsalted they were always abundant but in the salted cheese their appearance was variable, as is shown below.

The conclusion from these tests supports the observation of the previous year that temperature does exert an influence on their production, their appearance being much more marked at 40° than at the higher temperature.

II. *Effect of salt.*—Where cheese were salted in accordance with the usual rule (2½ lbs. per 1,000 lbs. milk) and duplicate cheese of same make not salted, a marked difference in the appearance of the white specks was noted, as is shown in Table I.

TABLE I.—*Effect of salt on the production of white specks in cold-cured cheese (40° F.).*

	SALTED CHEESE.				UNSALTED CHEESE.			
Age of cheese (in months) when tested	2	4	6	13	2	4	6	13
	0	Few	Few	Few	Few	++	+++	+++
	0	+	+	Few	++	+++	+++	+++
	0	0	0	0	Few	++	+++	+++

0 = No specks. + = Specks present. +++ Many specks present.

In the case of the cheese cured at 60° F., the only instances in which white specks appeared were in normal cheese made with no salt, and even in these, they disappeared under the influence of this temperature as noted above.

Salt evidently then represses the formation of white specks and this raises the question as to whether these compounds may not be soluble in saline solutions.

Influence of rennet.—Some of these cheese were made with normal amounts (3 ounces) of rennet and some with 9 ounces, in order to test the possible effect of rennet on the production of specks. In Table II the data observed are presented.

TABLE II.—*Influence of rennet on the production of specks in cold-cured cheese (40° F.).*

	Amount of Rennet Used.							
	3 ozs.				*9 ozs.*			
Age in mos. when tested	2	4	6	13	2	4	6	13
Unsalted	Few.	++	+++	+++	......	......	......	......
Unsalted	Many.	++	+++	+++	......	......	....	.... ..
Unsalted	......	......	......	......	Few..	++	+++	+++
Salted	0	Few..	Few.	Few..	......	......	......	......
Salted	0	Few..	Few..	Few.	......	......	......	......
Salted	....	......	......	......	0	0	0	0

In the case of the 60° cheese specks appeared temporarily in two instances where three ounces of rennet were employed, but none in the third case where nine ounces of rennet were used. This was noted only in the unsalted cheese.

It appears from this that an increase in rennet tends to diminish the formation of specks although the effect of salt is more marked than that of rennet.

Effect of color.—As these specks are dull, opaque, white bodies, it was thought that they would be so inconspicuous in the uncolored cheese as to be unnoticeable. Therefore part of the above cheese were made with the usual amount of color and part left uncolored. In both of these lots specks appeared equally conspicuous, their presence being determined by the other conditions above referred to, temperature, salt, etc. In the uncolored cheese they are distinguished by their opacity as compared with the translucent appearance of broken-down casein. When present they can be most easily discerned by holding a thin slice of cheese toward the light.

Effect of fat.—In all of our cold-cured cheese, observations have been recorded on the appearance of white specks and these in general confirm the data given. Additional information has been obtained in a series of cheese made from milk containing various amounts of fat, ranging from skim milk to eight per cent. In these cases specks were much more abundant in the cheese made with little fat. In the skimmed cheese they were abundant even in the cheese cured at 60° F.

Effect of acidity.—In a series of cheese made from sweet curds and cheddar curds, no specks were noted in the sweet-curd cheese at 15°, 33°, and 60° F., while the cheddar curds invariably possessed them at the lower temperatures. This indicates that the formation of acid in the cheddar curds is an important factor in their production, although at the present time the significance of this relation is not understood.

GENERAL CONCLUSIONS.

The chief factors determining the formation of white specks in cheddar cheese seems to be that of temperature and salt. Low temperatures favor very much the production of these specks. Rarely do they appear at 60° F. except where other conditions are peculiarly favorable for their production.

The addition of salt tends to prevent their formation under all conditions. Also they are not so apparent when increased quantities of rennet are used. They are especially abundant in skim cheese but do not appear in very rich cheese even at low temperatures. In sweet curd cheese no specks were found at any temperature.

RELATION OF CROP PRODUCTION TO AMOUNT OF WATER AVAILABLE AND METHODS OF CULTIVATION.

A. R. WHITSON.

The four year rotation of crops, started by Prof. F. H. King, has been continued this year. This is: oats seeded to clover, clover, potatoes on manured clover sod and lastly, corn. The oats have been cut before ripe and cured as hay.

The rainfall this year has been exceptionally large and well distributed as shown by the following table.

Rainfall at Madison, April to September inclusive, 1902.

Date	Rainfall in inches	Rainfall in 10 day periods.	Date.	Rainfall in inches.	Rainfall in 10 day periods.	Date.	Rainfall in inches.	Rainfall in 10 day periods.
April			June			July		
5	.14	....	7	.20	....	29	....	2.41
6	.05	....	9	....	1.18	30	.35	....
10	....	.19	11	.12	....	Aug.		
18	.43	....	12	.74	....	7	.07	....
20	....	.43	13	.02	....	8	....	.42
22	.18	....	14	.06	....	9	.09	....
25	.29	....	15	.45	....	10	.21	....
28	.08	....	19	....	1.39	12	.06	....
30	....	.55	20	.09	....	13	.21	....
May			25	.61	....	15	.01	....
1	.06	....	28	.12	....	18	....	.58
2	.15	....	29	.56	1.28	28	.06	.06
3	.38	....	30	.42	....	31	.01	....
4	.30	....	July			Sept.		
6	.34	....	2	1.52	....	5	.54	....
10	.74	1.97	3	.22	....	6	.70	....
12	.30	....	6	.80	....	7	....	1.25
13	.47	....	7	.81	....	8	.27	....
16	.02	....	8	.32	....	17	.02	.29
18	.68	....	9	.18	4.21	21	.05	....
20	....	1.47	14	.24	....	22	.05	....
21	.49	....	16	.31	....	24	.02	....
22	.08	....	17	.03	....	26	.04	....
23	.74	....	18	1.36	....	27	....	.16
25	.41	....	19	.34	2.28	28	.01	....
30	....	1.72	20	.40	....	30	.18	....
June			22	1.04	....	....	....	....
2	.51	....	23	.41	....	....	....	....
3	.10	....	25	.09	....	....	....	....
6	.37	....	27	.47	....	....	....	....

HAY CROP.

Owing to the openness and mildness of last winter the clover was entirely killed and the continued wetness of this season caused the grass brought in by the irrigation water of last year to grow so strongly that it was necessary to cut it frequently to prevent it from killing the clover of this year's seeding. There was no opportunity, therefore, to determine the yield under the otherwise favorable season.

Plot 1 was planted with oats seeded to Turkistan alfalfa on May 2nd. The oats were cut July 17th and the alfalfa October 2nd.

Plot 5 was planted with oats seeded to clover but the rank growth of oats and their lodging killed the clover so badly that it was plowed after the oats were cut.

Plot 6 was also planted with oats seeded to clover but the oats were cut early, before they began to head out to prevent the killing of the clover.

The yields of hay containing 15 per cent. moisture are given below:

	Plot 1.	Plot 5.	Plot 6.
1st crop in tons per acre.	2 303	2.776	1.205
2d crop in tons per acre	1.002	....	1 037
Totals	3.305	2.776	2.242

YIELD OF CORN.

The two plots in the regular rotation of crops which grew corn this year, Nos. 2 and 7, were planted with Pride of the North corn in hills 33 inches apart and rows 36 inches apart.

At no time in the growing season would it have been possible to irrigate wthout injury, and the corn was not quite mature enough for the best silage-making when cut.

The yield of corn on the stalk is given in tons per acre of silage, and of pounds of dry matter, and of ear corn in bushels per acre of 70 pounds of corn containing 15 per cent. of moisture.

	Plot 2.	Plot 7.	Average.
Tons of silage per acre	14.540	18.718	16.629
Pounds of dry matter per acre	7,851	9,172	8,511
Bushels of corn per acre, 70 lbs., 15 per cent. moisture	64.84	68.64	66.76

It will be interesting to compare these results with the yields of last year on similar adjacent plots in the same rotation but irrigated to make up for the deficient rainfall.

The planting was a little closer in 1901, being 30 × 36 inches, whereas it was 33 × 36 inches this year. The per cent. of dry matter in the silage was very nearly the same for the two years.

Yield of corn on irrigated ground in 1901.

	Plot 5.	Plot 6.	Average.
Tons of silage per acre	15.60	14.28	14.94
Pounds of dry matter per acre	8,102	7,406	7,754
Bushels of corn per acre, 70 lbs., 15 per cent. moisture	....	....	65.3

The corn stubble was left about four inches longer this year than ordinarily, which would make the difference greater than the table shows.

It will be seen on comparing the two tables, that the growth of corn, both of stalks and of ears, was greater during the cold, wet season of 1902 than during the hot, dry season of 1901 when water was added by irrigation to make good the deficient rainfall. The most of the difference was in the stalks, in spite of the thinner planting of this season.

EFFECT OF IRRIGATION ON THE SOIL.

We are learning to recognize two kinds of soil fertility: the first, that which determines the immediate productiveness of the soil; and the second, that which determines the productiveness which the soil will have as years go on.

The first is due to the store of material in the soil already available to the crop, and the second is due to the rate at which material not yet available is being changed into forms in which it is available to plants.

In studying irrigation, therefore, we should study the effect of supplementing the rainfall not only on the immediate crop but on the crops following those which are irrigated. An excellent opportunity has been offered this year to do this on a plot of ground which has been cropped to corn without manuring for eight years and part of which has been irrigated, whenever the rainfall has been deficient, and part left unirrigated.

The average amount of water added for the eight years has been about five inches, but in 1901 about eight inches were put on. This year it has not been necessary to supplement the rainfall, so all parts of the plot have received the same amount. The effect of previous irrigation on the soil has been quite noticeable, and is shown in the following table.

Table giving the yield of silage in tons per acre in 1902, on ground, part of which has been, and part of which has not been irrigated in previous years.

	Manured 1902.	Not manured.
Irrigated previous to 1902	13.581	11.524
Not irrigated at any time	16.010	12 358

This difference may be due to either or both of two causes. It may be due to the reduced fertility produced by the growth of larger crops on the irrigated ground during dry years, or it may be due to the washing of the soil by irrigation water.

YIELD OF POTATOES.

One of the plots of potatoes this year—No. 4—has been in the above mentioned rotation, on clover sod, while the other, No. 8, was on an old alfalfa sod, both manured at the rate of 20 loads to the acre.

The excessive rains made it impossible to irrigate without the certainty of injuring the crop.

The yields have been as follows:

	BUSHELS PER ACRE.		
	Large.	Small.	Total.
Plot 4 — rotation	309.1	33.7	342.8
Plot 8 — alfalfa	263.6	14.1	277.7

On account of the baking and cracking of the rather clayey soil as a result of drying in the latter part of August after the heavy rains, an unusual number of potatoes were sunburned. These amount in the case of plot 4 to slightly more than 12 per cent. of the large ones as given above, and in the case of plot 8, which is on higher ground, to nearly 5 per cent.

The yield of potatoes this year has been considerably less than on the irrigated ground last year. The average yield last year of large potatoes on irrigated ground was 362 bushels per acre, while the yield this year on the plot most nearly comparable—indeed, situated between those of last year—was only 309 bushels.

This difference would seem to be due chiefly to the continued coldness and cloudiness of this year as compared with last year. It may also be due to the hardness of the soil, which could not be cultivated much on account of rains.

To serve as a basis for the study of our crop yields with reference to amount and distribution of rainfall, we give a table showing the distribution of rain in ten-day periods for the growing season during the past 21 years.

Rainfall in ten day periods from April to September, inclusive, for the years 1882 to 1902 at Madison.

	1882	1883	1884	1885	1886	1887	1888	1889	1890	1891	1892	1893	1894	1895	1896	1897	1898	1899	1900	1901	1902
Apr. 1-10	2.51	No records	1.24	.99	.12	.00	1.28	.19	1.03	.38	2.07	1.02	.81	1.06	.69	.27	.21	.10	.00	.33	.19
Apr. 11-20	1.44		2.56	1.49	1.00	.20	.15	1.06	1.13	.54	.48	2.21	.98	.00	2.19	.81	1 61	.06	1.37	.12	.43
Apr. 21-30	.26		.71	.97	1.52	.80	.92	.46	.06	.53	1.39	1.30	1.83	.00	.56	1.42	.56	2.54	.00	.00	.55
May 1-10	1.19	1.31	3.11	.34	1.48	.99	1.53	.45	3.0[illegible]	.07	3.95	1.12	1.57	1.31	1.30	.28	1.41	1.05	.91	.89	1.97
May 11-20	.91	3.02	.25	.36	.53	.55	1.46	1.42	1.23	.00	1.31	.30	1.42	.91	2.56	.32	2.35	1.01	.82	.05	1.47
May 21-30	.34	2.65	.85	.98	.01	.43	.67	1.14	.79	1.33	.79	.62	.42	.38	2 26	.14	.75	2.72	.13	1.43	1.72
May 31-June 9	2.04	5.03	1.52	3.54	.49	.24	.00	.69	3.26	1.23	3.93	1.61	.00	.26	.93	.79	.11	1.03	.76	.16	1.18
June 10-19	1.15	2.09	1.21	54	.30	.57	2.21	1.14	2.52	.77	2.64	4 31	1.83	.21	.84	1.29	1.58	1.16	1.07	1.97	1.39
June 20-29	2.55	.45	1 84	1.03	.29	.06	.64	.17	1.69	1.70	2.00	1.01	2.11	.27	.82	1.95	2.87	.45	1.37	.29	1 28
June 30-July 9	4.17	1.78	3 02	2.16	.41	4.26	1.24	.51	.47	1.85	1.01	2.77	.00	.02	.77	.65	.29	2 54	2.74	.12	4.31
July 10-19	.05	2.26	.21	1.74	.14	1.11	.17	.49	.81	.02	.15	1.64	2.04	.55	.41	.46	2.55	.48	2.92	.41	2.28
July 20-29	.01	4.85	5.15	3.37	.24	.27	.72	1 12	.78	.80	.96	.23	.31	.46	2.39	.67	.10	.24	1.45	1.07	2.41
July 30-Aug. 8	2.60	.40	1.52	2.80	.38	.23	.74	.55	1 50	.18	.51	.04	.25	.07	.27	.82	.95	2.16	.10	.00	.42
Aug. 9-18	3 57	.37	.72	.64	3.36	3.09	.39	.05	1.11	.19	.24	1.38	.65	.01	1.25	.70	1.20	.37	.75	.85	.58
Aug. 19-28	.05	1.97	1.91	2.70	1.23	.66	.27	.12	1 62	.76	2.84	.00	00	1.54	.96	.32	.44	1.01	1.76	.52	.07
Aug. 29-Sept.7	2.41	.93	2 32	.34	.27	3 84	.20	1.32	1.01	.29	.76	.00	1.62	.08	.40	.68	.49	.30	.09	.00	1.25
Sept. 8-17	.53	.54	1 37	3 24	.76	1.21	.53	.38	.38	.00	2.51	.00	2.30	.35	2 07	1.67	1.02	.46	.62	3.43	.02
Sept. 18-27	.06	.92	.51	.22	1.34	1.26	.28	.23	.23	.00	.01	1.07	.00	.01	1.01	.00	.04	2.65	.79	.00	.18

Assuming that under our climatic conditions the maximum crop of corn and potatoes can be produced with 18 inches of rain during the growing season, of oats with 12 inches, and of hay with 24 inches, the table shows that during the last 21 years the average shortage of rainfall has been: for oats 1.4 inches, for corn and potatoes 3.5 inches, and for hay 5.7 inches. Or, expressed in a better way, there has been a shortage of 4 inches or over on 10 years during the corn and potato season, on 12 years during the hay season, and on 4 years during the oat growing season.

AMOUNT OF WATER USED BY THE SOY BEAN.

In view of the claims of drought resisting qualities which are made for soy beans and other fodder crops, it seems desirable to collect as much data as possible on the amount of water actually used by these plants. An experiment has been made this year to determine the amount used by the soy bean per pound of dry matter produced.

The crop was grown on soil in a steel tank 9.8 feet long, 3.9 feet wide, and 4.75 feet deep, sunk in the ground. The soil from the hole had been placed in the tank foot by foot in the position it originally had. Determinations of the per cent. of moisture in the soil were made when the seed was planted and again when the crop was harvested.

On account of the heavy rains in June and July, water collected in the tile placed in the bottom of the tank, and was removed. It was also necessary to add water in August and September when the crop was growing rapidly. The crop was planted June 11th, and harvested October 2d.

Calculating the weight of the soil in the tank from the data determined by Prof. F. H. King in the same field, the amount of water lost by the soil was determined as given in the following table:

Table showing the per cent. of water in the soil on June 11th and October 2d, and the amount of water in the soil June 11th, in excess of that on October 2d.

DEPTH.	PER CENT. OF WATER IN SOIL.		Pounds of water June 11th in excess of Oct. 2d.
	June 11th.	Oct. 2d.	
1st foot	19.8	17.7	64.
2d foot	15.9	11.6	150.
3rd foot	13.5	8.8	185.
4th foot	8 8	5.0	152.
5th ½ foot	14.1	8.7	154.

This makes a total loss by the soil of 705 pounds. To this must be added the weight of the rain. This amounted between the dates of planting and harvesting to 13.9 inches, or, on the area of the tank, to 2,757.4 pounds. In addition to this, 388.5 pounds were added as above mentioned, making in all 3,850.9 pounds, while 140 pounds had been removed by drainage. The total amount of water used by the crop and evaporated from the soil amounted, therefore, to 3,710.9 pounds.

In harvesting the crop it was cut close to the ground. After thoroughly dry, it weighed 7.04 pounds. The plant therefore used 527 pounds of water per pounds of dry matter produced. The average of several determinations by Prof. King of the water used to produce a pound of dry matter is: for corn, 270.9 pounds; for oats, 503.9 pounds, and for clover, 576.6 pounds.

The amount used by the soy bean would, therefore, seem to be nearly twice that needed to produce a pound of corn, somewhat more than for oats, and somewhat less than for clover. The yield of soy beans was at the rate of 7,980 pounds of dry matter per acre, equal to 9,177 pounds of hay with 15 per cent. moisture, and the water used amounted to 18.68 inches.

The real meaning of the term "drought resisting," of course, is that the plant can exist for a time on a small supply of water, though it make small growth, and retain its vigor so as to renew rapid growth when the amount of water is increased. It is probable that the soy bean can do this; but the actual amount of water used in producing a pound is relatively large.

INFLUENCE OF THE SOIL ON THE PROTEIN CONTENT OF CROPS.

A. R. WHITSON, F. J. WELLS, AND A. VIVIAN.

The writers, as no doubt many others, have been surprised at the great variation in the per cent. of protein in our fodder and hay crops as given in tables of analyses.

It is well known that the protein content of most plants is relatively larger at the earlier stages of growth than at the later stages, and this without doubt is in part the cause of the variation mentioned. But in many cases this explanation seems insufficient and suggests that the soil, particularly the amount of nitrogen available to the plant, has a direct influence. It certainly is a very important fact, if it be a fact, that a rich soil not only produces more to the acre than a poor one, but that the crop is richer in protein, the most valuable food constituent.

In order to study this question, we have carried on experiments, in part in the plant house and in part in the field, on corn, oats, barley, rape and cow-peas.

In part of these experiments the nitrate has been added directly as a solution of sodium nitrate; in others as leachings from a very rich soil; and in still others is simply the result of more rapid nitrification in the soil. In all cases, however, we have determined the amount of nitrates in the soil at two or three stages previous to and at the time of making the determination of the protein in the plant. This was done, even in the cases when definite amounts of sodium nitrate were added, to avoid any error or uncertainty which might come from reduction or formation of nitrates in the soil.

The amount of available nitrogen in the soil is expressed

as parts of nitric nitrogen per million of the soil moisture. It is based on the soil moisture in order to make it possible to compare the richness of sandy soil when fertilized and loam and clay soils. A sandy soil may seem as moist with 5 per cent. of water as a clay loam with 15 per cent., and it is the strength of nitrates in the soil water that determines the fertility of the soil, at the time, with reference to the nitrogen feeding of the plant.

As a check on the determination of nitrates in the soil moisture the amounts of nitrate in the plants have also been determined. This is expressed as per cent. of nitric nitrogen in the dry matter.

The amount of proteid nitrogen has in all cases been determined by Stutzer's method and is expressed as per cent. of proteid nitrogen in the dry matter.

EXPERIMENTS WITH OATS.

Two series of experiments with oats were made: the first with oats grown in jars, and the second grown on a sand plot, both in the plant house.

Oats grown in jars.—Twelve four-gallon jars provided with glass tubes for ventilation after Wheeler's method were used. These were all filled with a soil consisting of five parts of plaster sand and one part of a clay loam from the field. These were planted to oats March 29th. After the seed was well germinated the jars were divided into three groups of four each; the first group was watered with lake water containing no nitrates, the second with an amount of leachings of a rich plant house soil with the lake water, and the third group with the same leachings twice as strong.

The object of this treatment was to grow the oats all on soil having a like physical composition, but having three grades of fertility as nearly like that of field conditions as possible. Determinations of the nitrates in the soil and plant were made on May 6th; of the nitrates in the soil and plant and of the proteid nitrogen of the entire aerial part of the plant, May 21st, and of the nitrate in the soil and proteid nitrogen in the seed July 1st.

Table giving the nitrates in the soil and plant and proteid nitrogen in the plant and seed of oats grown in jars.

Date.	Group of jars.	Parts per million of nitric nitrogen in soil water.	Per cent. of nitric nitrogen in dry matter of plant.	Per cent. of proteid nitrogen in plant or seed.	Part of plant.
May 6	1	110.3	.225	....	
	2	157.8	.464	....	
	3	210 2	.511	....	
May 21	1	7.1	.039	1 93	Entire plant.
	2	36.5	.513	2.53	
	3	45.0	.834	2.66	
July 1	1	4.5	....	2 39	Seed.
	2	28.5	....	3.06	
	3	147.6	....	3.07	

From this table it will be seen that the soil water was richest in nitrates during the earlier stages of growth, and decreased toward the close. The difference between the three groups was least at the beginning and increased as the crop grew. The changes in both these respects are like those which take place in the field. There the amounts of nitrates will increase in the spring till the crop begins to use them more rapidly than they are being formed, when they will decrease in amount. Later, during the last stages of development and ripening, the nitrogen of the straw is accumulating in the seed and not much is taken fom the soil, so that the amount there may increase. This resembles what occurred in group 3 as shown by the determination July 1st. Except, then, for the differences due to growth in the plant house rather than in the open air, the conditions were similar to those which would be found in a field of uniform character but varying in fertility.

The amount of nitric nitrogen in the plant, or that which has been taken by the plant from the soil but has not been transformed into protein, decreased greatly between May 6th and 21st in the plants growing in the poorest soil; increased slightly in the plants growing on soil of medium fertility, and much more in those on the richest soil. When we consider the proteid nitrogen or that which is contained in the protein, we see that the per cent. in the entire plant May 21st is, on the poorest soil, 1.93 per cent., equal to 12.06 per cent. of

protein; on the medium soil, 2.53 per cent., equal to 15.81 per cent. of protein; and on the richest soil to 2.66 per cent., equal to 16.63 per cent. of protein. In this case the per cent. of protein is 31.09 per cent. larger in the crop grown on ground of medium fertility, and 37.8 per cent. larger in that grown on the most fertile soil than in that on the poorest soil.

The crop May 21st was at a somewhat younger stage than it would be cut for hay, but not younger than it is often used for soiling. The seed on the poorer soil were not so well filled as on the better soil, and, as would be expected, the per cent. of protein was less.

Oats grown on a sand plot in the plant house.—The soil of the west side of the plant house consists of about 1½ feet of sand on a clay sub-soil. Rows of oats and rape were planted March 15th on this and after the seed had germinated it was divided into three plots, the first of which received no fertilizer, the second a small amount of sodium nitrate, and the third double this amount. The nitrate was dissolved in water and applied once a week till April 23d, and twice each week after that date, the amount being calculated so as to give on the second plot a medium rich soil solution, and on the third about as rich as would occur in a rich field soil.

The nitric nitrogen in the soil was determined in each plot on April 18th, in the plant on April 26th, and in both soil and plant on May 9th and 23d and June 6th, and the proteid nitrogen in the plant, then in bloom, on the last date. The nitric nitrogen in the soil and the proteid nitrogen in the seed were determined July 1st.

The average number of parts per million of nitric nitrogen in the soil moisture from April 18th to June 6th inclusive was for plot 1, 36.88; for plot 2, 135.62, and for plot 3, 300.27. The strength of the soil solution in the most highly fertilized plot was only three-fourths that of one of the field plots growing potatoes in 1901.

The amount of nitric nitrogen in the plants decreased from the first in the case of those receiving no fertilizer; increased rather strongly in the second plot at first, but decreased largely as the crop matured; while in the third plot there was a slight decrease toward the end, as shown by the following table:

Table showing the per cent. of nitric nitrogen in the dry matter of oats grown on sand plots in plant house.

	April 26.	May 9.	May 23.	June 6.
Plot 1, not fertilized	0.277	0.255	0.046	0 105
Plot 2, half fertilized..............	0 553	0.919	0.479	0.323
Plot 3, fully fertilized	0.620	0 931	1.002	0.843

On June 6th the per cent. of proteid nitrogen was determined when the oats were in bloom and was found to be, in plot 1, 1.29; plot 2, 1.63, and plot 3, 1.70, corresponding to 8.06, 10.19 and 10.63 per cent. of protein respectively. This indicates a gain in the per cent. of protein of 26.3 per cent. in the plot receiving the smaller amount of nitrate fertilizer, and of 31.88 per cent. in the plot receiving the larger amount.

The differences produced in the fertility of the soil by adding the sodium nitrate were no greater than those occurring in farm practice between poor and good soils, and we think it likely that as great differences may be found in the per cent. of protein in crops growing on poor and rich soils in the field as those found in this experiment.

The analysis of the ripe seed taken July 1st showed the per cent. of proteid nitrogen to be: on plot 1, 2.57; on plot 2, 2.79, and on plot 3, 2.77. These percentages are rather high and are probably due to the climatic conditions of the plant house in which the plants developed. It will be noticed that, while there is an increase in the seed of fertilized soil over those on soil not fertilized, the seed on the soil receiving the half and full treatment contained about the same per cent. of proteid nitrogen.

EXPERIMENTS ON CORN.

Experiments on corn have been carried on both in the field and in the plant house.

Corn grown in the field.—Corn has been grown in the field on three pieces of ground: (1) manured, (2) unmanured, (3) on soil planted to potatoes in 1901 on clover sod. Con-

stant differences have been found in the per cent. of proteid nitrogen in the manured as compared with both the unmanured and with the potato ground.

Comparison of crops on manured and unmanured land.—Part of the plot, No. 9, which had grown corn for several years without fertilizer was given a dressing of farmyard manure at the rate of twenty loads to the acre, while the remainder received no fertilizer. The entire plot was planted with Pride of the North corn in hills 33 × 36 inches apart, May 27th.

Determinations of the nitrates in the soil water and in the plant, and of proteid nitrogen in the plant were made at intervals during the season.

The first set of determinations on the soil and corn, made July 8, were on composite samples of each made by taking samples at regular distances throughout the length of the field. After that date the samples were all taken near the upper end of the field where the soil was poorest and where the effect of the manure on the crop was most noticeable. The results of these determinations are given in the following table:

Table giving the amount of nitric nitrogen in parts per million of the soil water and in per cent. of the dry plant and per cent. of proteid nitrogen in the plant, on corn ground, manured and unmanured.

DATE.	Treatment.	Nitric nitrogen in parts per million of soil water.				Per cent. of nitric nitrogen in dry plant.	Per cent of proteid nitrogen in dry plant.
		1st ft.	2nd ft.	3rd ft.	4th ft		
July 8	Manured	43.4	23 9	5.9	5 3	0 355	2.57
	Unmanured	50.0	19.7	....	3.8	0.379	2.99
July 29	Manured	3 0	8 8	4.3	5.2	0.169	1 80
	Unmanured	6 4	19.9	6 7	5 5	0.256	2.02
August 11	Manured	2.4	3.2	3 6	4 0	....	....
	Unmanured	8.7	21.7	6.3	5.8	....	....
August 25	Manured	....	....	....	....	....	0 94
	Unmanured	....	....	....	....	....	1 21
September 5	Manured	....	....	....	....	....	0 93
	Unmanured	....	....	....	....	....	1.02

The large difference between the amounts found the 8th and 29th of July is due in part to the actual difference in fertility of the parts of the field from which the soil was taken, as noted

above, in part to the growth of the plant and in part to the leaching caused by the very heavy rains of that month. It will be seen from these figures that the amount of nitrates in the soil has been larger in the unmanured than in the manured ground. The per cent. of nitrates and of porteid nitrogen in the plant was also greater on the unmanured land.

FIG. 21.—Corn from manured and unmanured land. The smaller bundle is from the unmanured land.

The yield of dry matter was: on the manured ground, 8,440 pounds per acre, and on the unmanured ground, 5,965 pounds per acre on the poorer end of the field where the samples were taken on and after July 29th. It will be seen, therefore, that, while the use of manure on this soil had the effect of decreasing the per cent. of protein in the crop, the total protein on the manured land was greater than on the unmanured.

The effect of the manure was much more noticeable during the earlier part of the season than toward the close. Fig. 21

is from a photograph of two bundles containing an equal number of stalks cut July 29th, the smaller bundle from the unmanured and the larger from the manured land.

The result of this experiment is of particular interest because—contrary to the general rule—the plants which made most vigorous growth contained the smaller per cent. of protein. It would seem that the stimulating influence of the manure had been chiefly due to something other than the nitrogen it contained, or at least to the nitrogen supplied the plant in the form of nitrates.

Corn grown on ground which grew potatoes in 1901.—This plot has been in the regular four-year rotation of crops consisting of oats seeded to clover, clover, potatoes on manured clover sod, and lastly, corn. The amount of nitrates developed in this plot in the summer of 1901 while growing potatoes was very large, and we therefore expected to have an opportunity to study the development of corn on ground containing large amounts of nitrates. Owing to the very heavy rains of June and July, however, the nitrates were either leached out of the soil to a large extent, or were reduced by bacteria. The difference in the protein of the crop on this ground and on that of the other plots was therefore less than it would have been in a season of ordinary rainfall. Still there has been a marked difference in the per cent. of protein of the crop on this ground as compared with that of the manured half of plot 9 as shown by the following table:

Table giving the amount of nitric nitrogen in parts per million of the soil water and in per cent. of the dry plant and per cent. of proteid nitrogen in the plant on manured ground and on ground which grew potatoes the year previous.

Date.	Plot.	Nitric nitrogen in parts per million of soil water.				Per cent. of nitric nitrogen in dry plant.	Per cent. of proteid nitrogen in dry plant.
		1st ft.	2d ft.	3d ft	4th ft.		
July 8	Potat'es 1901	62.0	34.2	7 9	5 5	0.632	2.79
	Manured....	43 4	23.9	5 9	5.3	0.355	2 57
July 29	Potat'es 1901	4.7	7.4	12 2	9 4	0.198	1.84
	Manured....	3.0	8 8	4.3	5.2	0.169	1.80
August 11........	Potat'es 1901	4 2	5 4	7.5	4 0	....	....
	Manured....	2.4	3.2	3.6	4 0	....	....
August 25........	Potat'es 1901	....	....	....	....	....	1 29
	Manured....	....	....	....	....	....	0.94

Expressed as per cent. of protein, the above amounts of proteid nitrogen are equal on July 8th to 17.437 and 16.062, on July 29th to 11.50 and 11.25, and on August 25th to 8.062 and 5.875 respectively. On the last date, August 25th, the corn was at the roasting stage and of equal maturity on the two plots.

The yield of dry matter on the ground which grew potatoes in 1901 was 9,172 pounds per acre, as compared with 8,440 pounds per acre on the manured ground, which had previously grown eight crops of corn without manure.

The difference in the per cent. of protein on these two plots cannot be due to failure on the part of either to make a vigorous growth, and would seem to be due to the greater abundance of nitrates in the soil of the plot which grew potatoes in 1901 and which were available to the corn, especially during the early period of growth.

But, whatever the explanation, the fact remains that the per cent. of protein was larger in the corn grown on ground which had been kept in a high state of fertility by a good system of rotation and manuring, than in corn grown on ground which had been reduced in fertility by continuous cropping, even when the yield is made nearly equal by a single application of manure.

FIG. 22.—Corn grown near and away from trees and showing the influence on the size of the stalks.

Effect produced by trees on the per cent. of protein in corn which is growing near them.—As an interesting example of the variation of the protein of corn due to difference in soil fertility, may be cited the case of corn grown this year on a plot bordered by a row of elms about 14 inches in diameter and 30 feet apart. The plot grew potatoes in 1901. and has had the same crop rotation as the one above cited and was therefore in a good state of fertility except near the trees.

The effect on the total yield was very marked as is shown by Fig. 22, which is from a photograph of bundles containing equal numbers of average sized stalks, the smaller bundle being from near the trees. Determinations of the protein were made on August 18th, when the photograph was taken, and again on September 5th, a few days before it was cut for silage.

On the earlier date the corn near the trees contained 0.97 per cent. of proteid nitrogen, and that away from the trees contained 1.31 per cent. On the latter date that near the trees contained 0.86 per cent., and that away, 1.09 per cent.

Experiments on corn grown in the plant house.—On July 15th the west side of the plant house was planted to corn, oats and rape, and three plots treated as described for the oats on page 195, i. e., one plot was watered with water free from nitrates, the second received a small amount of sodium nitrate twice a week, and the third double this amount twice a week.

On the same date corn, oats and rape were also planted on the east side of the plant house on clay loam soil originally from the field, but which on account of the climatic conditions of the plant house has become very fertile.

Determinations of the nitrates in the soil water were made at the time of planting, again on August 4th, and on September 2d, and of the nitric nitrogen and proteid nitrogen on the last date.

Table giving the nitric nitrogen in parts per million of the soil water and in per cent. of the plant and of proteid nitrogen of the dry matter of corn grown in the plant house.

PLOT.	JULY 15.	AUGUST 4TH.		SEPTEMBER 2ND.		Per cent. of nitric nitrogen in dry matter of plant.	Per cent. of proteid nitrogen in plant.
	Nitric nitrogen in parts per million of soil water, first foot.	Nitric nitrogen in Soil water.		Nitric nitrogen in soil water.			
		1st foot.	2nd foot.	1st foot	2nd foot.		
1...........	86.2	37 1	18 4	Trace...	Trace...	Trace.....	1.35
2...........	116 3	112.0	49 8	Trace...	15.8	0 156	1 59
3	479 6	316.5	92.6	91.4	41 9	0.469	1 80
East........	2031.7	....	....	1627.4	729.4	0.464	1.79

side was uniform and vigorous. The only noticeable difference was in color: the corn on plot 1 which received no addition of nitrates soon began to be somewhat lighter, while that on plots 2 and 3 was darker in the order of the amount of nitrates received.

As the small amount of nitrates in the soil of plot 1 was used up, the color became lighter and finally the lower leaves turned yellow, just as they were observed to do in 1900 in the field which had been reduced in fertility by continuous cropping without fertilizer. See Bulletin 85, p. 28.

The growth of the plants, however, on this plot kept pace with that of those on plots 2 and 3 nearly through the period of growth, and at the present writing (November 1st), the plants on plot 1 are only a few inches lower than on plots 2 and 3. Material has been saved at intervals since the last analysis given in the table above, but the determinations have not yet been made.

The corn on the east side of the plant house where the soil is very fertile, for the reason before given, has made more rapid growth, and while that on the three sand plots averages seven and a half feet November 1st when approaching maturity, that on the east side averages nine feet in height. Figure 23 shows the corn on plots 1, 2, and 3, as it was on September 13, and Fig. 24 that growing on the east side of the plant house.

The stalks on all plots are rather thin and the ears are small, due in part to the thicker planting and in part to growth in the plant house late in the season when the light is much less. Otherwise, the growth has been normal and the changes in the nitrates in the soil have been, both in amount and in manner, similar to those taking place in fields of varying fertility.

The results of this experiment would point toward four conclusions: first, that the per cent. of protein in the plant is dependent directly on the amount of nitrates in the soil; second, that corn on different fields may make very nearly equal growth while differing materially in per cent. of protein produced; third, that beyond a certain point the per cent. of protein is not increased by excess of nitrates; and, fourth, that in the presence of a sufficient amount of nitrates in the soil,

variations in the growth of the plant are caused by the amounts of salts in the soil other than nitrates.

It will be seen that in spite of the enormous amount of nitrates in the soil on the east side, the per cent. of protein in the plant was essentially the same as that in the corn of plot 3 on the west side. It would appear, therefore, that the soil of plot 3 contained as much nitrate as could be utilized by the plant.

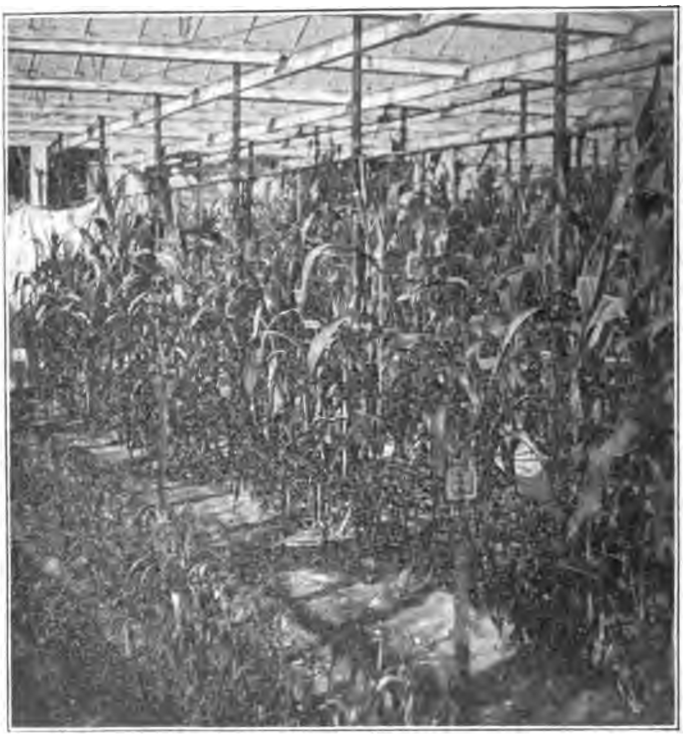

FIG. 23.- Showing corn on plots 1, 2 and 3 grown in the plant house.

Expressed as protein, the corn on plot 1 contained 8.44 per cent.; on plot 2, 9.94 per cent., or an increase of 17.8 per cent. in the per cent. of protein; and in that on plot 3, 11.25 per cent. of protein, or an increase over that on plot 1 of 33.3 per cent. in the per cent. of protein.

FIG. 24.—Showing corn on the east side of the plant house.

EXPERIMENTS ON COW PEAS.

In the plant house.—The cow peas were grown in the plant house in four-gallon jars arranged and filled in the same way as those on which oats were grown. See page 193. The peas were planted March 29th. The growth of the plants was much more influenced by the amount of fertilizer added than was any other crop experimented with. Soil leachings were added as in the case of the oats. A representative jar from each of the three groups of jars is shown in Fig. 25 from a photo taken July 29th. The color of the three differed as much as the size. Those receiving no fertilizer continued of a light green color and were less healthy than the others. Those which received the largest amount of fertilizer grew vigorously, reaching in the season a height of 7 feet, and were of a dark green color.

Determinations of nitrates in soil water and in the plant were made June 3d and 23d and August 6th, and of proteid nitrogen June 23d and August 6th, as shown in the following table:

FIG. 25.—Showing cow peas which have received different amounts of leachings of a rich soil. No. 1 received half as much as was given to No. 3.

Table showing the nitric nitrogen in the soil water in parts per million and in the plant in per cent. and of proteid nitrogen in the plant as per cent. of dry matter of cow peas.

Date.	Group of jars.	Parts per million of nitric nitrogen in soil water.	Per cent. of nitric nitrogen in dry matter of plant.	Per cent. of proteid nitrogen in dry matter of plant.	Height of plant, inches.
June 3.........	1	175.6	0.227	....	....
	2	658.5	0.519	....	....
	3	499.8	0 908	....	....
June 23........	1	36.4	0.031	2.00	8
	2	105 7	0.289	2.65	11
	3	378.8	0.459	2.96	11
August 6	1	6 3	0 027	1.52	15
	2	10.0	0 018	2.27	22
	3	27.2	0 167	2 59	36

While no attempt was made to sterilize the soil on which the cow peas grew, it did not contain tubercle forming bacteria.

About August 1st one of the jars of group 1 was inoculated with about a tablespoonful of soil from South Carolina on which the cow peas had grown. In October, at the end of the development of the plants, the roots in this jar were well covered with tubercles. On three of the other jars one or two small tubercles were found, doubtless formed by bacteria carried on the trowel to them from the inoculated jar.

The plants were therefore dependent for their nitrogn on the poor soil in the case of group 1, and on that and what was contained in the soil leachings in groups 2 and 3.

Experiments on cow peas in the field.—Cow peas were grown on very sandy soil at Stevens Point, Wis., on two plots. Plot 1 was on ground which bore a crop of cow peas last year and which was well inoculated with tubercle forming bacteria. The roots of the cow peas this year were therefore well covered with tubercles. Plot 2 had never before been planted with cow peas, and there were no tubercles on the roots of this year's crop till near the close of the growing season, when a few small ones began to appear.

Both plots were manured at the rate of twenty loads to the acre. The crops on the two plots made a very fair and nearly equal growth. A determination of the nitric nitrogen in the plants August 15th showed 0.691 per cent. in those on plot 1, and 0.265 per cent. on plot 2.

Samples of the entire plant above ground taken September 13th showed 2.975 per cent. of proteid nitrogen in the dry matter on plot 1, and 2.01 per cent. on plot 2. This amounts to a difference of 48 per cent. in the per cent. of porteid nitrogen.

There are two possible causes, either or both of which may have produced this difference. It may have been due to the grater supply of nitrogen made directly available to the plant by the tubercle bacteria during the growth of the plant, or it may have been due to the existence of larger amounts of nitrates in the soil as the result of the nitrification of the roots of last year's crop. Since no determinations of the nitrates in the soil of these plots were made, it is impossible to say which of these factors was more important. Experiments

planned to determine this point are not yet completed. But the important fact remains that with nearly equal growth, this crop may produce very different amounts of protein, dependent on the condition of the soil on which it is growing.

EXPERIMENTS ON RAPE.

As mentioned in the description of the experiment on oats, rape was grown on the three sand plots of the west side of the plant house, plot 1 receiving no fertilizer, plot 2 a small amount of sodium nitrate, and plot 3 double this amount.

The seed was planted March 15th. On June 6th the height of the plants on plot 1 was 18 inches; on plot 2, 24 inches, and on plot 3, 30 inches.

Determinations of the nitric nitrogen in the plant were made May 23d and June 6th, as shown in the following table:

Table giving the nitric nitrogen and proteid nitrogen in rape grown on sand in the plant house.

Plot and Treatment.	Nitric nitrogen in per cent. of dry plant.		Proteid nitrogen in per cent of dry plant.	Per cent. of protein (6.25)
	May 23.	June 6.	June 6.	
Plot 1, no fertilized	0.160	0.184	2.01	12.56
Plot 2, half fertilized	0.578	0.691	2.24	14.00
Plot 3, fully fertilized	1.074	1.266	2.28	14.25

Compared with plot 1, the per cent. of protein in plot 2 shows an increase of 11.40 per cent., and that in plot 3 shows an increase of 13.445 per cent. In this case the nitric nitrogen of the half fertilization was apparently about all that could be utilized by the plant in the formation of protein, and so the full quantity did not produce a very marked increase in the per cent. of protein. It is impossible to say whether or not the greater growth of the rape on plot 3 than on plot 2 is due to available nitrogen, though apparently not.

RESULTS OF EXPERIMENTS BY OTHER WORKERS.

In Germany some experiments have been made, chiefly by Adolf Mayer, to determine the relation between the fertility of the soil and the amount of protein in the plant. Barley for brewing purposes should be low in protein, and Mayer has shown that this cereal contains a smaller per cent. when grown on poor soil than on fertile soil.

The most important work in this line, however, is that done by Prof. C. D. Woods and his associates at the Connecticut station. They have shown that the fertility of the soil produces a marked difference in the per cent. of protein in the crop.

In one respect, however, their results were different from those we have found. They found that manure applied directly to the soil on which the crop grew, increased the per cent. of protein, whereas we found that while the total crop was largely increased and therefore the total amount of protein was larger on the manured than on the unmanured land, yet the per cent. of protein was larger in the crop on unmanured ground than in that on the manured ground.

No determinations of the nitrates, either in the soil or plant, were made by Woods, so we do not know what the effect of the manure was in this respect. Moreover, the percentage of protein was calculated on the basis of total nitrogen in the plant, as determined by the Kjeldahl method. This cannot give accurate results in the presence of nitrates in the plant. The error due to this must be small in the case of the seed, but may be considerable where the stalk and leaves are analyzed.

From the foregoing somewhat preliminary experiments, we would draw the following general conclusions: First, that most of our farm crops show large variations in the per cent. of protein at the same stage of their development. Second, that this variation may exist even when the crops are making practically equal growth. Third, that under similar seasonal conditions, the most important factor in causing this variation is the amount of nitrates in the soil.

EXPERIMENTS ON BLACK MARSH SOIL.

A. R. WHITSON.

The experiments with black marsh soil this year have been planned with reference to four points:

I. To compare treatment with potash fertilizer and green manuring.

II. To determine how long the beneficial influence of potash and manure will last.

III. To determine the effects of different amounts of potash.

IV. To determine the best methods of applying the potash fertilizer.

To compare the effects of potash and green manure, use was made of the large cylinders in the plant house filled with soil from the marsh land of the University farm. The 12 east side cylinders were filled with soil from a field which grew poor crops, and the 12 west side with a soil from a field which had grown better crops. These cylinders grew a heavy crop of oats during the winter. Of the 12 cylinders on each side, four were left blank; four were treated with 45 g. sulphate of potash, and the remaining four were given a green manuring by cutting up the oats which had grown on the same cylinder and working them into the soil.

The cylinders were then planted with four hills of corn each. On July 10th the corn was cut, grouped according to treatment, and weighed green. It was then allowed to dry in the plant house and weighed air-dry.

Table showing yields of green and air-dried corn on black marsh soil not treated, treated with potassium sulphate and with green manure.

Treatment.	East Side.		West Side.	
	Green lbs.	Air-dry lbs,	Green lbs.	Air-dry lbs.
Blank	11.1	2.9	26 2	4.7
Potassium sulphate	44.2	8.96	42.5	7.3
Green manure	42.4	8.60	36.1	6.0

From these figures it will be seen: (1) That in the case of the cylinders of the east side, which contain the poorer soil the application of potassium sulphate and of green manure has more than trebled the yield, as is shown in Fig. 26. (2) On the better soil the effect of both treatments is much less marked than on the poorer soil, as is shown in Fig. 27. (3) The application of the potash and of the green manure has made the poorer soil give a greater yield than the better soil. (4) The application of green manure was nearly as effective as the potash.

THE LASTING EFFECT OF POTASH AND MANURE.

Experiment in the greenhouse.—To determine the effect of the treatment with potash on the second crop grown, the west row of cylinders were planted again to corn on July 21st without additional fertilizer. This was cut October 4th, and the average weight on the cylinders which had received no potash with the first crop found to be 4.4 pounds, while the average of the cylinders which had received 45 grams with the first crop was 5.8 pounds.

Experiment in the field.—Corn was grown on the field, part of which had been given 20 loads of manure to the acre previous to planting the crop of 1901, and part had received no manure. This year this ground received no fertilizer, and the effect of the manure applied last year was to increase the yield this year of corn on the ear 35.1 per cent., and of stalks 20.5

per cent. In these cases the influence of the fertilizers on the second crop after application, while noticeable, is only a small fraction of the influence on the first crop.

FIG. 26.—Corn grown on marsh soil in east row of cylinders in plant house. The first bundle on the left was grown on cylinders which received no fertilizer, the second on cylinder which received potash and the third on cylinders which received green manure.

In the field, the corn this year did not show any effect of potash salts applied last season. It is probable, therefore, that the effect of the potash salt as applied in field work would be limited to the crop with which it is applied. On the other hand, the effect of a good dressing of manure has been noticeable the third season.

FIG. 27.—Showing corn grown on marsh soil in west row of cylinders in plant house. The first bundle on the left is from cylinders receiving no fertilizer; the second from cylinder receiving potash and the third green manure.

EFFECTS OF DIFFERENT AMOUNTS OF POTASH.

Since the extent to which the potash fertilizer will be used on this soil will depend on its cost, it is very desirable to determine how small an amount can be used with good results.

Studies have been made on this point this year both in the plant house and in the field. In the plant house four cylinders were used which had grown one crop of corn and one of oats since any potash had been applied. Four hills of corn were planted on each cylinder and after it had gotten above ground, 15 grams, or about one-half ounce, of sulphate of potash was worked into the soil of one cylinder; 30 grams into the second, 45 grams into the third, while the fourth received no potash.

The weight of green corn fodder produced on these was: (1) 7.18 pounds, (2) 7.80 pounds, (3) 8.22 pounds, (4) 2.54 pounds.

While the yields stand in the order of amounts of potash, they are very far from being in proportion to them. In this case, the smallest amount was the most profitable. The four hills on each cylinder might be considered equal to three hills as grown in the field, so that under conditions as favorable as those of the experiment, five grams or about one-sixth of an ounce, would appear to be sufficient to give good results. This with corn three feet apart would be at the rate of about 50 pounds per acre.

Not anticipating that so small an amount as that above mentioned would be effective, greater quantities were tried in the field, namely, twelve and twenty-four grams to a hill. At no stage in the growth of the corn, nor at the harvest, could any difference between these be seen. The smaller amount was just as effective as the larger.

The cost of the fertilizer where from 50 to 75 pounds per acre are used, would be between $1.25 and $2.00 per acre.

Method of applying the potash.—The most important question still remaining unsolved is the method of applying this fertilizer in field practice.

In the experiments, both of Prof. King and of the writer, the potash has been put around the hill of corn after it was up a few inches, and working it into the soil somewhat with the hands. This, of course, is not practicable in farm practice, and we are now trying to find a way of applying it with a corn planter. The difficulty is, that if the potash is put directly in the hill with the corn it will prevent the kernels from absorbing water and so hinder or prevent their germination.

Experiments have been made on this soil in the plant house in order to determine how much can be placed directly in the hill with the corn, and whether placing it below the corn a reasonable distance would obviate this difficulty.

Five groups of four cylinders each have been planted with corn: four hills, of four kernels each, in each cylinder. In group 1, each hill was treated with 4 grams of potassium sulphate; in group 2, 8 grams; in group 3, 12 grams; in group 4, 16 grams, and in group 5, 20 grams. In the first cylinder

in each group the potassium sulphate was placed directly with the corn; in the second it was placed one-half inch below; in the third, one inch below, and in the fourth, one and a half inches below the kernels of corn.

The corn was planted in this manner October 15th, and on October 25th and November 1st the number of kernels in each cylinder which had germinated was determined as shown in the following table:

Table showing the number of germinated kernels in each cylinder after the application of different amounts of potassium sulphate and at different depths.

NUMBER OF GRAMS IN EACH CYLINDER.	Position of the fertilizer.	NUMBER OF SEEDS GERMINATED IN EACH CYLINDER.	
		Oct 25th.	Nov. 1st.
4	With seed	4	6
	½ inch below seed	6	7
	1 inch below seed	11	16
	1½ inches below seed	6	10
8	With seed	8	14
	½ inch below seed	2	5
	1 inch below seed	1	6
	1½ Inches below seed	8	9
12	With seed	0	1
	½ inch below seed	6	8
	1 inch below seed	6	8
	1½ inches below seed	7	10
16	With seed	0	2
	½ inch below seed	9	10
	1 inch below seed	4	9
	1½ inches below seed	9	9
20	With seed	1	5
	½ inch below seed	4	7
	1 inch below seed	1	3
	1½ inches below seed	7	14

While the table shows a wide variation in the individual cylinders, the average with reference to amount of fertilizer used and to depth of application shows considerable influence of both factors on the germination.

Thus, out of the 64 seeds treated with 4 grams of potassium sulphate, 39 developed; with 8 grams, 36 developed; with 12 grams, 27 developed; with 16 grams, 30 developed, and with 20 grams, 29 developed. The influence of depth was more pronounced. There were 80 seeds with each depth of appli-

cation of fertilizer, and of these 28 germinated where the fertilizer was placed with the seed; 37 where it was placed one-half inch below; 42 where one inch below, and 52 where one and one-half inches below.

Two cylinders were also planted with corn with no sulphate. Out of the 32 seeds planted in these, 26 germinated.

It will be seen from these results that the potassium sulphate must be placed at some distance below the seed in order not to prevent its germination. Just how far this must be remains to be determined by field experiments on a larger scale. It would appear safe to use the sulphate at the rate of 50 to 75 pounds per acre if it can be placed one and one-half to two inches below or at one side of the seed. We have not been able to find a corn planter which will do this, but believe one can be constructed for this purpose.

SUMMARY OF RESULTS.

The effect of the potassium sulphate is limited to the first crop, while manure may influence the second crop largely and the third somewhat.

With the ordinary distance of planting of corn, 50 to 75 pounds per acre would appear to be the most profitable amount to use.

In order not to prevent germination, this must be placed from one to two inches below or at one side of the seed in the hill.

EXPERIMENTS WITH GRAIN AND FORAGE PLANTS, 1902.

R. A. MOORE.

The season of 1902 was unfavorable for cereal crops. The excessive rains of July, followed by almost continuous cloudy weather, caused the grain to grow to such a height, that nearly all was carried to the ground, where it filled imperfectly and much grain sprouted. The weather conditions were favorable to the growth of green forage and root crops, of which large yields were harvested.

A table of meteorological data for Madison from observations taken at the Washburn Observatory, from April to October, 1902, is herewith given:

Meteorological data for Madison, Wisconsin. April to October.

	April.	May.	June.	July.	Aug.	Sept.	Oct.	Total Apr.—Sept.
Mean temperature	44.1	59 8	63.2	71 3	66.8	58 2	51.4	....
Normal mean temp	46 7	57.3	57 8	73	70 4	62.8	50 2	....
Mean highest temp	55.2	68.8	71.1	79 0	75 5	65 7	59.4	....
Mean lowest temp	36	50.9	55.2	63 6	59 4	50 7	43.5	....
* No. of heat units	1323	1853.8	1896.	2210 3	2070.8	1746.	1593.4	12693 3
Normal heat units	1401	1776.3	1731.0	2263	2182.4	1884.	1556.2	12796.9
Total precipitation in inches	1 17	5.16	4 27	8 98	.78	4.18	1.23	25.77
Normal precipitation	2.90	3 9	4.68	3.8	2.85	3	2.3	23.43
No. of rainy days	6	14	14	17	8	12	8	79
No. of clear days	3	3	3	4	11	8	9	41

* Mean daily temperature multiplied by the number of days in the month.

I feel especially indebted to A. J. Meyer, special agent of the Bureau of Plant Industry, Washington, D. C., for his ef-

NOTE.—No distribution of seed can be made this year as the supply on hand will be needed for future experiments by the Station and former students of the College of Agriculture who are carrying on comparative tests.

ficient assistance during the past season in crop experiments here reported, and in keeping records of the same.

THE WISCONSIN AGRICULTURAL EXPERIMENTAL ASSOCIATION.

Former students of the College of Agriculture have formed an organization named The Wisconsin Experimental Association. The purpose of this organization is to conduct simple experiments, such as the testing of new varieties of farm grains, plants, commercial fertilizers, methods of crop culture, insecticides, etc., under direction of the various investigators in the Experiment Station. It is the plan of this Department to supply at reasonable cost from time to time members of this organization in the different counties, with quantities of seeds to be tested, in order to learn their worth under practical farm conditions. When it has been found that a given variety of grain, for example, has proved really meritorious under such tests, the persons having first secured the seed will endeavor to multiply the quantity of grain by growing the sample, and to supply their neighbors therewith at reasonable cost. It is believed that work of this kind will prove of great help to the state and that through this Association the Station can best distribute seed to farmers wishing to grow new varieties. Next year, persons wishing a list of growers of new varieties of seeds in their county may gain the desired information by sending a two-cent stamp or stamped envelope, together with request, addressed to Agricultural Experiment Station, Madison, Wis.

VARIETY TESTS OF GRAIN.

The work of previous years was continued this season and variety tests were again made of cereals that were considered promising. The severe storms during the months of June and July so badly lodged all grain, that the yields could not be ascertained, and no attempt will be made in case of the spring grains, to give the yield of grains and straw per acre or weight of grain per measured bushel in this year's report.

Barley.—Eleven varieties of barley were on trial. The Manshury and Oderbrucker seem to outclass other varieties as to yield and excellence in quality. Both are six-rowed varieties

and are noted for stiffness of straw and plumpness of berry. Salzer's Silver King and Minnesota Golden Queen gave excellent returns and seem to be identical with that of the Manshury variety. Several varieties of two-rowed barley were tested and gave fairly good returns, but the straw was so weak that the first severe storm carried it to the ground, which prevented it from filling properly and thereby reduced the quantity and quality of the grain.

Oats.—Seventeen varieties of oats were tested; the following gave good returns and showed commendable characteristics; Wis. No. 4 (Swedish), No. 26 (Iowa Silver Mine), No. 34 (Wisconsin Wonder), and No. 17 (White Bedford).

The Swedish oats, the seed of which was secured from the United States Department of Agriculture in 1899, seem to be the most satisfactory of any on trial in the four years' test, and an effort will be made to grow this variety in large quantities so that the farmers of the state will be able to secure seed direct from the Station or from former students and seedmen who are growing them. Last year two hundred bushels of the Swedish oats were sold to former students of the College of Agriculture living in different counties of the state, two bushels to each student, and from recent reports received excellent yields were obtaind in nearly all counties; in many instances a yield of 80 bushels per acre and above was secured. It seems quite conclusive that through the introduction of the Swedish oats that the oat crop of Wisconsin will be raised several bushels per acre.

Reports to hand from the various parties growing the oats indicate the desire to retain all oats grown this season for seed for the coming year. In another year the Swedish oats (Wis. No. 4) will be within the reach of nearly all farmers of the state desiring them.

The Station will keep a record of all who are growing the oats for seed and in 1903 a list will be furnished on application to any one desiring to purchase this variety of oats.

Rye.—Two varieties of fall rye were tested: the Schlansted and Petkus, both German varieties secured by the Bureau of Plant Industry from Europe for the U. S. Government in 1900

and sent to the Wis. Experiment Station for trial purposes. These varieties of fall rye are said to be of the best in Europe for bread-making purposes.

They have proven very satisfactory in a two years' test and have been carried into the field plots this fall for the purpose of growing in larger quantities.

The Petkus gave the larger yield and seems the most hardy. During the severe frosts of last winter the plots of rye were completely exposed to the elements, and while the Schlansted rye suffered severely and a part was winter-killed, no trace of damage by frost or otherwise could be detected in the plots of Petkus rye. Further trials to note hardiness and yield per acre will be continued. The yields of these two varieties for the past two years were as follows:

	Name of variety.	Yield per acre.	Weight per measured bushel.
1901	Petkus Rye	37.8	57
1901	Schlansted Rye	36.7	56
1902	Petkus Rye	41.4	58
1902	Schlansted Rye	29.2	56.5

II. VARIETY TESTS WITH FORAGE PLANTS.

Soy Beans.—The soy bean is a native of Asia and belongs to the great family of plants known as "leguminosae." It is said to still grow wild in some parts of China where it forms an essential part of the food for the inhabitants. It is used extensively as a human food in Japan, where it derived its name, and to a limited extent in the United States. Its principal use in this country is for forage and a soil renovator.

The plant was introduced into the United States years ago, mainly through the instrumentality of Prof. Georgeson of the Kansas Agricultural College, but was confined chiefly to Kansas and the southern states. Until quite recently no extended effort has been made to grow it in the north. The value of the soy bean as a forage and seed-producing plant has been clearly demonstrated by several experiment stations and its general use as such is rapidly being extended in the United States.

Typical plants of the soy bean, with leaves removed and with leaves remaining, are shown in Fig. 28.

FIG. 28.—Soy Beans. The rate of yield from best variety, 38 bushels dry beans per acre.

Eight varieties were tested at this station, the seed of which was donated by Mr. Edward Evans, West Branch, Michigan, and includes some of his choicest varieties. The object of our variety test was to ascertain whether the soy bean can be successfully grown in this state, and to determine the most satisfactory varieties for seed and forage-producing purposes.

In tests made during the past two years at this Station we have found that from two to ten tons of green forage, or two or three tons of cured hay could be procured from an acre of soy beans.

The soy bean plant when green or cured is eaten readily by all farm animals and is noted for its high protein content. The late varieties produce a very rank, coarse growth which is hard to cure. The leaves fall off quite readily if allowed to get too dry after cutting. If the desire is to cut for hay, it is a good plan to sow broad-cast about one bushel of seed per acre and to cut the crop at the first appearance of small pods.

When used for soiling purposes, cutting can be begun at the first appearance of blossoms and continued until the ripening period. The earlier dwarf varieties should be sown when the object is to secure seed and the medium early varieties when the desire is to use the plant for silage or as a soiling crop. When the desire is to grow the soy bean for grain sow in drills about thirty inches apart between the rows and four inches apart in the row, using about one-half bushel of seed per acre. The time for planting is approximately the same as that of corn. In this it differs from the cow pea, which can only be planted later in the season.

No attempt has yet been made at this Station to determine the value of the soy bean as a silage crop, but the Tennessee Experiment Station found soy bean silage very high in feeding constituents.*

Soy beans were planted with corn to determine if they would make sufficient growth to warrant sowing them in corn that was to be used for silage. The beans at first did not appear to start well, but later made considerable growth and stood approximately three feet high at the time of cutting the corn. The early

*1896, Vol. 9, p. 106. Professors F. E. Emery and B. W. Kilgore in bulletin 87d, 1892, N. C. Experiment Station, have the following to say: "The soy bean is one of our most promising crops. The soy bean silage has been fed in our stables long enough to give assurance of its value. The high percentage of protein in proportion to carbohydrates gives the silage a narrow nutritive ratio and this indicates that it can be used to good advantage as part of a ration of hay and straw with corn, or corn and oats, or mixed with corn silage."

variety was used, which was not preferable, as a much taller growth could have been secured by the "Michigan Green," which grows vigorously and reaches a height of four feet or more.

It seems that by growing soy beans with corn and cutting the same for silage, a high grade of silage could be obtained that would be very important as a food for dairy animals and other stock; the soy bean would help to balance the ration, giving it more protein or flesh-producting substances, the component low in corn silage. As growing soy beans for silage alone or with corn is purely in the experimental stage, further trials will be made the coming year with that end in view.

The different varieties of soy beans tested on the experimental plots, with yield of dry beans per acre and other data, will be given in the following table:

Name of Variety.	Growing period.	Yield per acre in bushels.	Weight per measured bushel.
Ito San	136 days	33 7	56
Early Brown	136 days	16 5	56
Med. Early Black	133 days	14.3	54.5
Med. Early Green	135 days	22.3	56
Med. Early Yellow	136 days	38	54
Michigan Green	162 days	28.7	58
Wisconsin Black	122 days	23	54.5
Early Black	133 days	17.3	52

INOCULATION EXPERIMENTS WITH SOY BEANS.

Through the action of certain micro-organisms, which inhabit nodules grown upon the roots of leguminous plants, free nitrogen is taken from the air and used for the purpose of building up plant tissue. By the decay of the nodules and roots of the plants which contain large quantities of nitrogen, a supply is left in the soil, which will be available for other crops. The renovating properties of the clover is known to every practical farmer, although he may not be aware of the reasons for such beneficial results.

It seems conclusive that the plant and soil are helped by the growing of leguminous crops, especially where the nodules develop on the roots of such plants. Clover has been grown

for many years in Wisconsin, consequently the variety of bacteria which form nodules on the roots of the clover plant is everywhere present and nodules soon form on the young plants and begin the performance of that work which plays such an important part in agriculture.

It has been found in some parts of the United States that clover and alfalfa would not do well until the ground was inoculated with the proper bacteria, but after such inoculation the plants thrived and reached normal growth. It seems that what is true of clover and alfalfa in some states is true of the soy bean in Wisconsin. In 1901 soy beans were grown as a forage and seed-producing crop on our experimental plots and several tests were made at different intervals to determine if nodules could be found on the roots of the plants. No nodules were, however, found and a further test was made to determine if nodules would form if soy beans were planted on the same plots on which soy beans were grown the previous year. The variety of seed grown last year was used for this year's test and of approximately 100 plants examined, only two plants were found on which any nodules had developed, the others showing no growth of nodules whatever.

A test was made to note the effect of inoculation of the soil on the development of nodules and for this test ground that had never grown soy beans was selected. Two plots, containing 1-20 of an acre each, were set apart for this experiment and these inoculated with a preparation made as follows: Four quarts of dried soy bean nodules, donated by Mr. Edward Evans, West Branch, Mich., were put in a box which was partly filled with mellow soil, and the mixture was then thoroughly saturated with water. After a few days about 50 lbs. more soil was added and again moistened, this mixture being left for a week and then sowed on the plots where the soy beans were to be planted. Several times during the growing period tests were made to determine if tubercles were forming, and in each case they were plainly noticeable.

A sample of the root development was taken for photographic purposes on the plot inoculated, and another on a plot that was not inoculated, with results as seen in Fig. 29. No percepti-

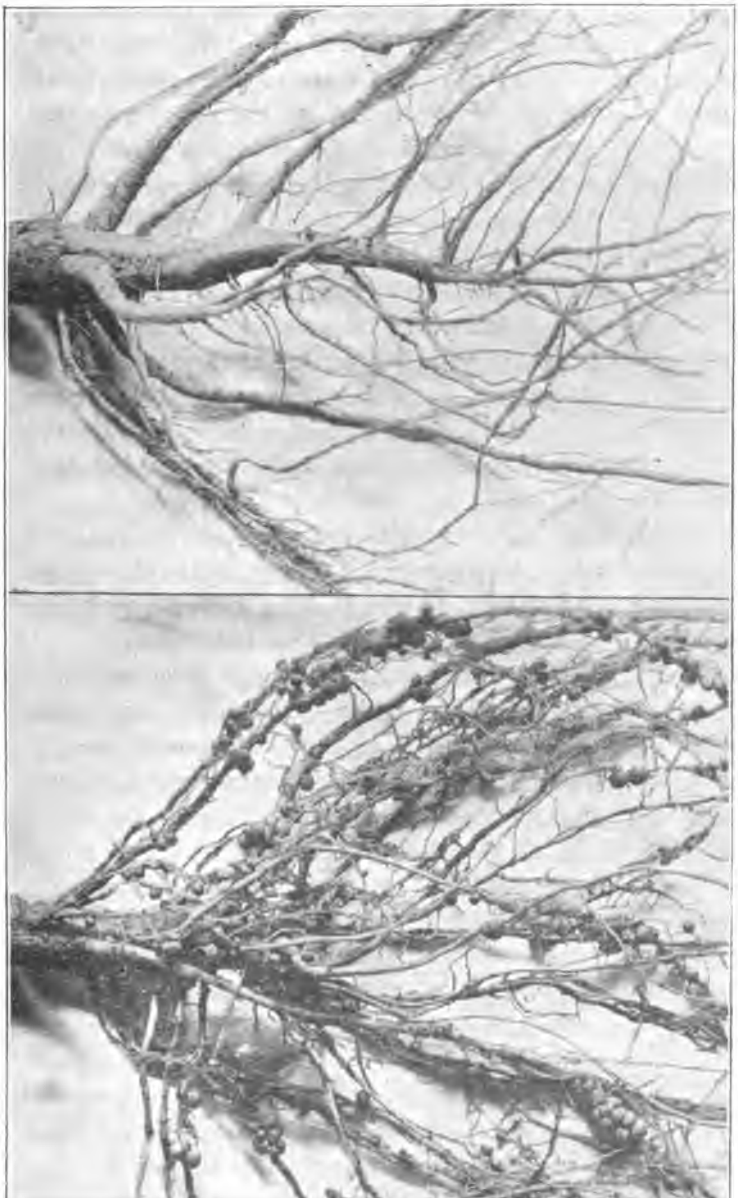

FIG. 29.—Showing the development of nodules on the roots of soy beans as the result of inoculation of the soil with the proper bacteria. The plant on the left grew on soil that was inoculated and that on the right on soil that was not inoculated.

ble difference could be noted as to growth of plants on the plot inoculated and that which was not. The plots in each case were on fairly rich soil and the plants probably received sufficient nitrogen from the soil and did not need the assistance of the bacteria in getting their supply. As the plots inoculated were pastured, no comparison as to the yield was made.

The soil on the plots inoculated is filled with bacteria which seem to help the physical condition of the soil, as well as add nitrogen for future use of plants.

Cow Peas.—Six varieties of cow peas were tested to determine their value as a forage and seed-producing crop. The wet cold season was unfavorable for their growth and the vines seemed stunted from the start, so that during a portion of the season the plants looked sickly and many died. Those left revived during the latter part of the summer and made a fairly good growth of vines and pods.

The Red Ripper and New Era gave the best returns, and seem the best adapted to this region. The varieties above mentioned gave a yield of from 10.8 to 13.7 bu. per acre, weighing 52.5 and 50 lbs., respectively, to the measured bushel.

The cow peas do not ripen evenly and some varieties do not ripen at all in this latitude. Pods were picked last season from the early-maturing plants of the Whippoorwill variety of cow peas, and planted this season to note the effect on early maturity. No difference could be detected between the period of maturity of plants grown from the early and late plants of last season. No nodules were found on any of the roots during this or last season. Trials will be made the coming year by inoculating the soil with the proper organisms to aid in the development of nodules and note the effect on the plants.

The cow pea seems to be strictly a southern plant and can not stand the cold rains or climatic conditions of the north and it will be well for farmers to refrain from growing them extensively until more experience as to their value under our conditions is at hand. It is barely possible that in some of the sandy portions of the state the cow pea may become important as a soil renovator and a forage-producing plant.

Alfalfa.—During the past few years tests have been made by the writer in growing alfalfa for hay and as a soiling crop.

In the first trials the common varieties were used and one of the serious difficulties met with was the fact that a large portion would winter-kill and the remainder would be crowded out by weeds and grass which would take the place of the dead plants. The location of the plots was not the most favorable, as they were on low ground, and during the spring when the snow was melting rapidly and the occurrence of frequent rains the water would submerge the plots for several hours at a time, which may have aided in the eradication of the alfalfa.

The common alfalfa, while producing a fair crop the second season, viz., from three cuttings 3.6 tons of hay, seemed to lack vitality and vigor and the plots were plowed and put into grain the third season. Further tests were made with the Turkestan variety of alfalfa. April 25, 1901, several plots were seeded to Turkestan alfalfa, with oats as a nurse crop, the seed germinated well and the young plants were everywhere noticeable. The growth of oats seemed to aid in keeping down the weeds, and as there were no indications of lodging, the oats were left to ripen. The oats were cut July 26, and in a few weeks the plots were covered with a fine stand of alfalfa which was left for winter protection. One plot was sown with alfalfa without a nurse crop, but the weeds grew more rapidly than the alfalfa plants and would have crowded out the alfalfa if they had not been frequently pulled. No attempt was made to pull any weeds from the plots that were seeded with the nurse crop, as the dense growth of alfalfa and nurse crop kept them well under control.

To get a fair test as to the amount of forage that could be grown on a given area seeded with and without a nurse crop, two adjoining plots were taken that had been seeded accordingly and these were cut at intervals, and the green forage weighed. Three cuttings were made and the weights showed that the plot seeded with the nurse crop yielded 17.1 tons per acre, and the plot seeded without, 15.8 per acre. The cuttings were made earlier each time than that made on adjoining plots that were cut for hay, and it seemed to have a detrimental effect, each plot suffering in the same manner.

The plots adjoining on either side where the alfalfa was cut

for hay look much more vigorous and have a much thicker stand than on the plots where the green forage was taken, although no difference could be noted at the time when the plots were first cut. Cutting before the plants receive a certain growth, therefore, apparently in some way injures alfalfa.

Production of Alfalfa Seed.—An effort was made to produce seed from the second cutting, but notwithstanding the fact that the plants flowered profusely, only an occasional seed was formed.

The plots reserved for hay (see Fig. 30) were cut three times and averaged a total yield of 4.5 tons per acre.

The different cuttings of Turkestan Alfalfa gave the following amounts of hay per acre for the season.

Date of cutting:	Amount of hay per acre in tons.
1st. June 5	2.4
2nd. July 17	1.
3rd. Sept. 2	1.1

A hardy variety of alfalfa seed was obtained from the Minnesota Experiment Station and was sown on one of the experimental plots April 16, with barley as a nurse crop. The extreme wet weather had a detrimental effect on the alfalfa as it caused the nurse crop to grow so rank that it lodged badly, smothering most of the young alfalfa plants. The plants remaining look vigorous and tests will be made to note their ability to withstand freezing the coming winter.

Fall seeding of Alfalfa.—To note the effect of sowing Alfalfa in the fall several plots were seeded to the Utah variety of alfalfa August 19, 1901. The seed germinated well, and October 15 a dense green growth four inches in height covered the plots. The winter was very severe as there was little snow for protection and nearly all plants died. So few plants were left that it was not deemed advisable to continue the experiment further, consequently the plots were plowed up and put into other crops.

Notes relating to growing Alfalfa.—From tests made during the past four years the following observations have been noted:

To get a good catch of alfalfa (1) Sow in the spring on fall-plowed land as soon as the ground is in good condition.

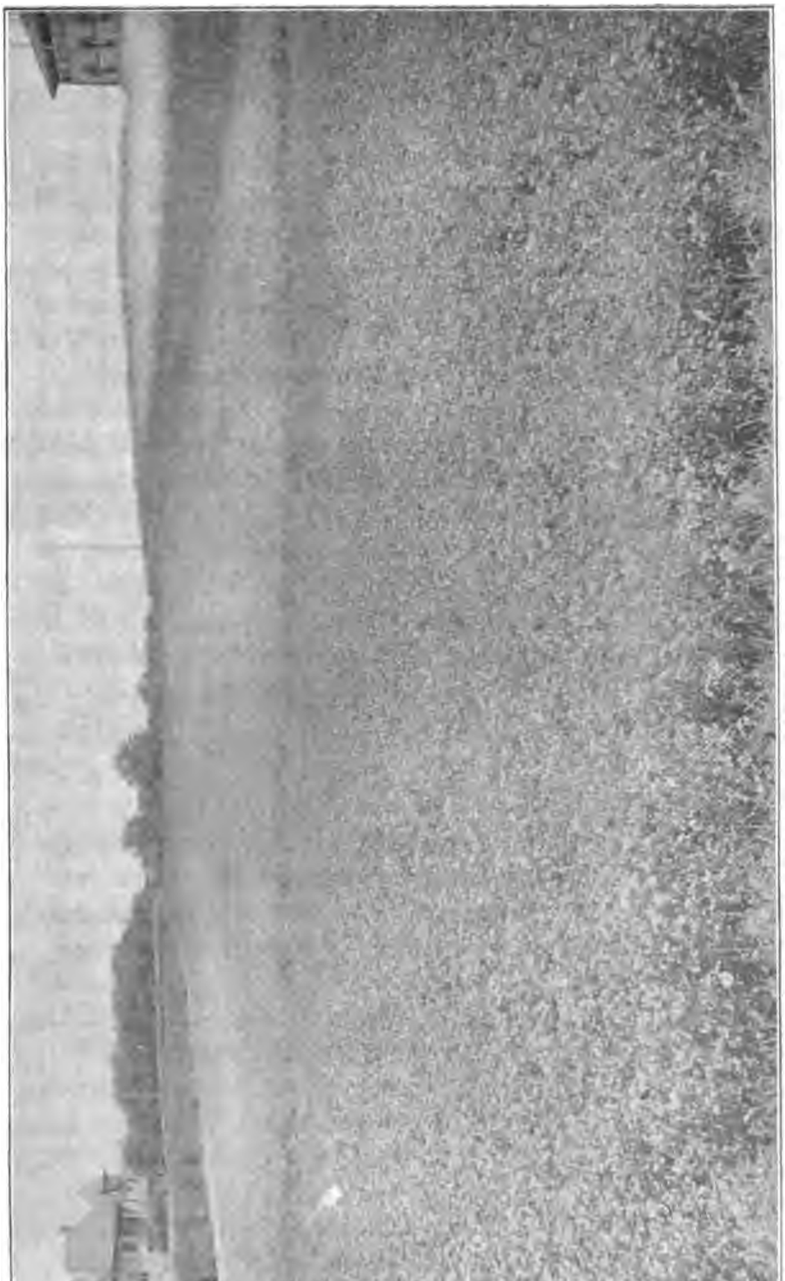

FIG. 30.—Turkestan Alfalfa. Yield 4½ tons hay per acre from three cuttings.

(2) Carefully prepare the seed-bed with disk harrow or good cultivator and sow at the rate of 20 lbs. of seed per acre. (3) Sow on well-drained land that has good porous subsoil, and if inclined to be weedy sow oats as a nurse crop at the rate of one bushel per acre. If oats are inclined to lodge cut them, as they will smother the alfalfa if left to lie on the ground. (4) If the ground is very clean alfalfa can be sown without a nurse crop and will usually give one cutting of one ton of hay per acre the first season; three cuttings should be secured the second season in the southern part of the State. (5) Turkestan alfalfa has shown superior drought and frost-resisting qualities compared with the common varieties, but the quality of the hay and green forage obtained was no better than with these. (6) Alfalfa will not stand being pastured to any great extent or being closely cut late in the fall. (7) Alfalfa makes a very desirable hay or soiling crop and is relished by all farm animals. No more difficulty is experienced in curing alfalfa for hay than with rank growths of clover. (8) A good catch of alfalfa can be obtained when the season is too dry and hot for clover. When desired for hay alfalfa should be cut when the first blossoms begin to appear.

VARIETY TESTS OF CLOVER.

In the spring of 1901 a co-operative experiment with the United States Department of Agriculture was started with native and European varieties of red clover, to determine their hardiness, productiveness and general adaptability for Wisconsin conditions. In this test ten varieties were used, but on account of the long protracted drought of the season of 1901, the young plants all died and the experiment was ruined.

This season a similar experiment was started with sixteen different varieties, viz.: Minnesota No. 12541, Bohemian No. 12669, English No. 12171, Galacia No. 12667, Styria No. 12666, Missouri No. 10990, Russian No. 12540, Italy No. 12635, Hungarian No. 12665, Michigan No. 11813, Sicilian No. 12664, Nebraska No. 12189, English No. 12174, Russian No. 12169, New Zealand No. 12173, and Danish No. 12172. The different varieties of clover were seeded without a nurse

crop on April 19th on fall-plowed land and on May 21st they stood an inch in height, and comparatively a good catch was obtained on most plots. The weeds came on rapidly and a mower was run over the plots June 18, July 19 and August 20, clipping the weeds and the tops of the clover plants so as to get the weeds under control. Very few weeds were noticeable after the third clipping and a nice even stand was secured on plots seeded to the Missouri No. 10990, Minnesota No. 12541, Nebraska No. 12189, Michigan No. 11813 and English No. 12174.

The other varieties seemed to lack vitality and only a partial stand was secured. The cold rains of the spring seemed to affect the young plants in a detrimental way and the weeds coming on vigorously took possession of the ground. A marked difference is plainly noticeable at this writing, October 6, in favor of the plots seeded to the varieties above named.

HUNGARIAN BROME GRASS.

The trials with Hungarian Brome Grass (*Bromus Inermis*) were continued to determine its value as a forage and seed-producing plant. The season was wet which favored the growth very much, and a yield of 2.1 tons of hay per acre was secured. A small plot was left to ripen for seed. The seed secured will be used to continue further trials the coming season. During the three years' test we have found that Brome grass makes a quick growth and a strong sod. In earliness it is at least two weeks in advance of our common grasses and furnishes pasturage for two or three weeks later in the season.

It produces an inferior grade of hay to that of timothy or red top and the yields have been comparatively light. During the hot dry weather of summer it withers and remains practically dormant for several weeks, but starts fresh and vigorously on the approach of the fall rains.

The seed is as yet quite expensive, $2.00 per bushel of 14 pounds; about one bushel is required to sow an acre.

Our farmers are advised to experiment in a small way with Brome grass until more is learned of its value.

Vetch.—During the past three years, vetch has been grown as a forage and seed-producing crop on the experimental plots. The difficulty experienced with the vetches lodging badly when sown alone, was overcome to a certain extent by sowing with fall grain. The sand or hairy vetch was used for this purpose and seed grown the previous year on the Wisconsin farm was sown August 19, with rye or winter wheat as a nurse crop. Three plots, 1-20 of an acre in size, were thus seeded and produced an excellent growth during the fall which would have afforded good pasturage for sheep or cattle. The vetch as well as the rye or wheat were sown at the rate of one bushel per acre. None of the plants apparently winter killed and a healthy growth was soon noticeable in the spring. A heavy stand of vetch and fall grain was secured. One plot of rye and vetch was used for green feed and gave a cutting of 12.7 tons per acre on May 16.

The other plots were left for hay and gave a cutting of 3 tons per acre, but on account of the severe rains and damp weather practically all was rendered unfit for use.

Observations.—From the four years' experience in growing vetch, we have noted the following:

1. When sown without a nurse crop on our rich loam, the vetch lodges badly, and very little use can be made of it. If pastured early, sheep relish the young plants, but after lodging, which the vetch do after a foot high, the older portions of the vines begin to decay and stock will not eat them either while growing or when cut for hay.

2. On account of the trailing nature of the vetch the undergrowth of vines when sown alone will decay early, thereby making it difficult to harvest and unfit for forage.

3. Very little seed will mature under our conditions, either when sown alone or with a crop for support.

4. If sown with a grain crop, some of the vetch ripens and when threshed is difficult to separate as the seed is nearly of the size of the common cockle found in wheat and other grains.

5. The sand vetch makes a fine fall and early spring pasture, especially when sown with winter rye.

6. Numerous nodules accumulate on the roots of the sand

vetch; this leads us to believe that it is a strong nitrogen gatherer and has an important office to perform in renovating sandy or worn-out soils.

FLAX.

Two plots of flax were tested to determine the value of this crop as a seed and fiber producing plant. The plots were given a good dressing of manure and then plowed and dragged. The flax was sown broadcast and harrowed in the usual way on May 16. The young plants were soon noticeable above the ground and appeared to do well until after the flowering period, when both plots of flax began to wither and look sickly from some disease which could not be identified.

Very little seed developed and the plants were so badly affected that the crop was cut and burned; some flax tried in the nursery plots was affected in the same way.

Further trials will be made the coming year.

SORGHUM.

Sorghum was introduced into the United States from China and South Africa about fifty years ago, and is now grown quite extensively as a forage- and syrup-producing crop in many of the states. There are two distinct classes, known as saccharine and non-saccharine sorghums. The saccharine sorghums are so called on account of their high sugar content while the non-saccharine sorghums are very low in this substance.

The saccharine sorghums are of particular interest to the people of the northern states as they can be grown to better advantage under our climatic conditions than the other varieties. For several years sorghum has been grown successfully as a forage crop on the University Farm. During the past season trials have been made to test the amount of green and dry forage that could be procured from a definite area and to note its value as a soiling crop for farm animals.

The variety used for trial purposes was the Early Amber and a plot, 1-20 of an acre in size, was sown July 18th, after removing a crop of rye and vetch. The seed was sown in drills

18 inches apart, using at the rate of 2 pecks of seed per acre. After appearing above ground the growth was very slow for about three weeks; it then seemed to take on new life and shot up vigorously, producing an abundant growth of excellent forage. The sorghum sown June 18th after another crop had been taken from the ground gave a cutting of 9.75 tons per acre of cured forage. The plot of early sown sorghum gave a cutting of 25.5 tons green feed and 9.7 tons cured forage per acre. (See Fig. 31.)

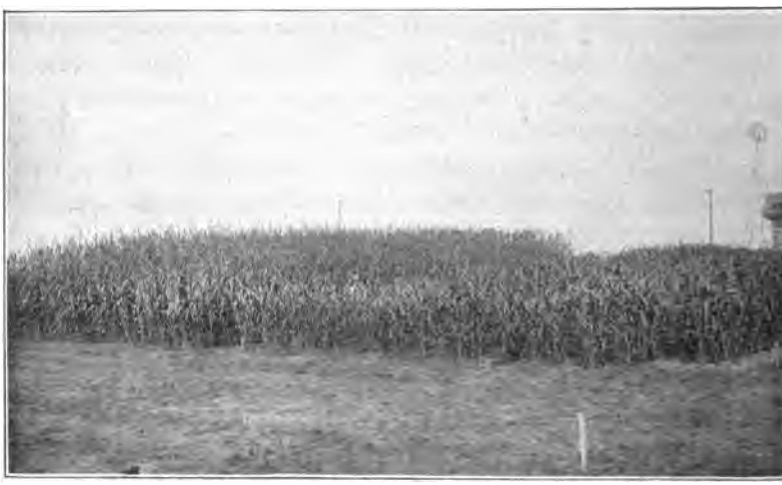

FIG. 31.—Sorghum. Showing on the left early planting and on the right planting on a plot after a crop of rye and vetch were removed.

Sorghum has been grown by Prof. Carlyle on the Experiment Station farm for several years as a soiling crop for cows and young stock. It has been found a very satisfactory feed for dairy animals.

It should not be cut until it begins to tassel, as previous to that time it has a bitter taste which prevents stock from eating it well.

Further tests will be made to determine its value as a soiling and silage crop.

OAT SMUT INVESTIGATIONS FOR 1902.

From investigations made by the writer, former Short-Course students and farmers throughout the state for several

seasons, large quantities of smut in oats have been found prevalent in the growing grain in all the counties of the state where tests have been made. Judging from tests made with a hoop in accordance with instructions given in Bulletin 91 and from reports, approximately fifteen per cent. of the oat crop of 1902 has been found to be destroyed by smut. The loss throughout Wisconsin to farmers is enormous, amounting to several million dollars annually. This amount could practically all be saved by the proper treatment of the seed grain.

Different methods of treatment have been employed from time to time, but the one most simple and effective is the formaldehyd treatment. The fact that smut could be eradicated from oats and other grains by the use of a formaldehyd solution was first noted in this country in 1895, by Professor H. L. Bolley, Fargo, North Dakota, then connected with the Indiana Experiment Station, and various ways and methods of applying the solution have been devised by the different Experiment Stations to best suit the conditions of the farmers.

Experiments have been carried on at the Wisconsin Station to determine, first, the prevalence and quantity of oat smut in the state; second, the natural increase of smut in oats without treatment; third, the strength of solution most desirable to use; fourth, the proper application of the solution; fifth, the amount of grain that can be treated with a given amount of the solution, and sixth, the time of exposure of grain to the solution.

The investigations have revealed that oat smut was prevalent in all portions of the state to the extent of approximately fifteen per cent. of the entire crop. The natural increase of smut in case of a variety of oats that was affected to the extent of ten per cent. in 1899 has been as follows: 1900, 20 per cent.; 1901, 31 per cent., and in 1902, 55 per cent.*

From investigations made by the writer and reports from former Short-Course students, druggists, and farmers in general it is safe to say that no less than 10,000 farmers treated their seed grain to prevent smut during the past season and hundreds of

*Bulletin 91, p. 3.

reports at the office of the Experiment Station show that in nearly all cases the treatment was wholly effective, or nearly so.

In a few instances seed oats that had been treated by farmers with the strength of solution formerly recommended (one pound of formaldehyd to fifty gallons of water) were found to have a light sprinkling of smut; this is accounted for in several ways: First, Some farmers have merely sprinkled the seed oats with the solution instead of submerging; the second, Some cases the oats have only been submerged two or three minutes, instead of twenty as recommended.

Other inaccuracies may have crept in from variation in the strength of the solution. Formaldehyd should be a forty per cent. solution, which is considered standard by druggists, and the strength used for our previous experiments.

Tests have been made to determine how strong a solution could be made without materially affecting the vitality of the seed grain. Four plots, one-fortieth of an acre in size, were used in these tests, which were sowed to oats April 21st at the rate of three bushels per acre. The oats used on plot No. 1 were Wisconsin No. 4, free from smut, and that used on the other plots were Wisconsin No. 2, which the previous year had been affected with smut to the extent of thirty-one per cent.

For plot *one* the oats were not treated; for plot *two* the oats were submerged twenty minutes in a solution made at the rate of one pound of formaldehyd to fifty gallons of water; in case of plot *three* a solution was used made up from one pound of formaldehyd to twenty-five gallons of water, and in case of plot *four*, one pound of formaldehyd to ten gallons of water. The oats on the three plots were sown broad-cast immediately after treatment and harrowed in the usual way.

The oats germinated well and came up approximately at the same time. No perceptible difference could be noted in the germination, growth or time of maturity of the oats seeded on plots Nos. 2, 3, and 4, which were of the same variety and treated as above noted.

From this experiment it seems quite likely that little danger will be experienced from treating seed grain with a solution considerably stronger than that heretofore recommended as prefer-

able in order to do away with any of the discrepancies above cited.

METHOD PRESCRIBED FOR THE TREATMENT OF SEED OATS TO PREVENT SMUT.

If the desire is to sow forty bushels of seed oats or less, secure from your druggist one pint of formaldehyd. Put into a barrel or tank thirty-six gallons of water and pour in the pint of formaldehyd liquid to make the proper solution. Place about two bushels of oats in a gunny sack and submerge the oats in the solution for ten minutes; then lift the sack from the barrel and allow it to drain for a minute or two in order to save solution. Empty the oats on a threshing floor or on some outside platform to dry and proceed as before. The oats will dry more quickly if shoveled over at frequent intervals.

If a large quantity of seed is to be treated the work will be facilitated by having several barrels or a large tank which will hold a number of sacks of oats, so as to treat several bushels every ten minutes. The time saved by having an abundant supply of the solution in the tank or barrels will more than repay for the extra expense of the formaldehyd purchased. When the quantity of solution in the barrels has been diminished, less oats must be put into the sacks, as the oats must always be completely submerged.

It is well to treat seed grain several days before sowing in order to give it ample time to dry, or some difficulty will be experienced sowing with seeder or drill. If sown while damp the seeder or drill should be set so as to sow one bushel more per acre than when sowing dry oats.

A formaldehyd solution of the strength recommended is not poisonous and will not injure sacks or clothing coming in contact with it. Oats treated with formaldehyd solution can be fed to stock, but when so fed should be mixed with other oats.

The treatment of oats facilitates the sprouting and gives the grain a healthy, readily distinguishable appearance. It is possible that the treatment kills other disease germs of which we yet have no knowledge as well as the smut spores.

From experiments carried on by Mr. Cranefield* it was found that the formaldehyd treatment when used at the

strength recommended prevented some of the seed from germinating. From the complete tests made it seems quite conclusive that such is the case, but it certainly is a benefit to the seed oats to have those seed of low germinating power eradicated and much may be gained by so doing. The question of the benefits derived by treating seed grain is no longer in the experimental stage; it has been established that there is a great benefit by eradicating the smut, not only in yield of grain per acre, but in quality as well. Grain dealers are discriminating against smutty grain and some will not take smutty oats at any price. The method prescribed for the treatment of seed oats will also eradicate the barley smut and one of the varieties of smut on wheat ("The stinking smut of wheat").

Farmers and seedsmen should put forth every effort to treat all seed grain in accordance with the recommendations given during the coming year and thus save millions of dollars that are being lost annually on the oat crop.

PLANT BREEDING.

The importance of plant breeding is now attracting attention in many states and efforts are being put forth by Wisconsin to give the farmers of the state the benefit which must necessarily result from the systematic breeding of varieties of grain that surpass any now grown in yield and desirable qualities. The benefits derived by animal breeding are no longer in doubt and practically all farmers use care and judgment in selecting sires and dams for the improvement of their herds and flocks. The care and judgment exercised in breeding and grading live stock is commendable and we hope that similar advantages that have come to our stockmen by getting the rounded or blocky form of the beef animal and the wedge-shaped dairy animal will more than be surpassed by the breeding of new varieties of grain and forage plants so as to still further the possibilities lying along the lines of animal production.

Through efforts put forth by the Minnesota Experiment Station in breeding wheat, the yield has been raised several bushels

*18th Annual Report, pp. 327–336.

per acre thereby adding many million dollars to the value of the annual crop of that state. The improvement in sugar content of the beet through careful breeding has now made this root crop of great economic and commercial value to the civilized world.

Methods of breeding.—The two principal methods employed in plant breeding are known as selection and hybridization.

Breeding by selection may be accomplished in two ways: 1st, by growing many plants under like conditions and selecting for further tests a few that show superior characteristics, and 2d, by selecting those spikes or heads of plants that show a marked superiority over others grown on the same plant under similar conditions.

By hybridization we strive to acquire by cross polination of plants belonging to the same species, but differing in their individual characteristics, the desirable quality predominant in each.

The work attempted the past season was by the former method, which is also used largely by the Minnesota Station. The ground selected for the plant-breeding nursery is a rich clay loam and plots 62 by 4⅓ feet were arranged that would hold approximately 2,000 plants, four inches apart each way; these were planted by using a planting frame so constructed as to enable the operators to plant rapidly at the desired distance apart.*

Grains that had shown excellent qualities in field tests were used for the foundation stock, viz.: nine varieties of oats, ten of barley, one of spring wheat. These were planted and kept carefully weeded during the season. Holes were made about two inches deep by using a dibble and two or three seeds were dropped into each hole. More than one seed was used in order that if a single seed failed to germinate, the space would still be occupied and no plant would have the advantage over its neighbors by being supplied with more sunlight, moisture or soil fertility.

When the plants were about two inches in height the grain

*Professor W. M. Hays and his assistants of the Minnesota Experiment Station have devised a planter which simplifies the method of planting in nursery and centgener plot work.

was thinned to a single plant four inches apart each way. The weaker plants were pulled, leaving the most promising ones for maturing. The nursery plots should be carefully weeded from the time the plant first makes its appearance until the grain has sufficient growth to completely shade the ground.

Observations were made from time to time and notes recorded regarding the condition of the plants and nursery in general. At maturity the nursery plots were closely scanned and the progeny of twenty of the most promising plants from each plot selected, all the commendable characteristics of the plants being taken into account in the selection. The heads of grain from twenty mother plants on each plot were clipped with scissors and put into envelopes, each being carefully weighed and labeled. Ten envelopes of grain from each plot giving the best weights were retained to be sown next season in little squares containing 100 plants; these squares are known as *centgener plots.* Each centgener plot will have 100 plants, the progeny of a single mother plant.

If the grain from ten mother plants of each nursery plot is retained we can have ten centgener plots next season for each variety of grain started in the nursery. No work has as yet been done with centgener plots, but the plan to be followed will be as herewith given. The grain in the centgener plots is planted in the same manner as that in the nursery.

The grain from the centgener plots is threshed separately and put into small sacks and weighed, the grain giving the best weight and record from two of the ten plots is retained and carried into the field plots to be tested the following year and compared with other varieties.

The work of breeding was begun this season, consequently we were unable to carry the work any further than the first step, which consists of the nursery-plot work only. The grain acquired from the mother plants will be retained and carried into the centgener plots next season.

Several choice varieties of winter wheat and rye have been recently planted in the nursery plots and tests will be made with these the coming season.

SUGAR BEET EXPERIMENTS DURING 1902.

F. W. WOLL AND R. A. MOORE.

The sugar beet experiments conducted at this Station during the past season were confined to co-operation with the Bureau of Chemistry, U. S. Dept. of Agriculture, in their study of the influence of environments on the beet root. In addition, a number of samples of sugar beets grown by Wisconsin farmers were analyzed in order to furnish information as to the quality of the beets harvested by these parties. No beet seed was distributed for trial purposes in the spring of 1902. The investigation of the adaptability of the soil in different parts of the state to the culture of sugar beets is considered closed, work along this line having been continued for twelve years past by this Experiment Station.

The land on the University farm on which sugar beets were grown during the past season was a little over one-third of an acre in area. The soil is a clay loam, with a heavy clay subsoil. It has a strong tendency to bake after rains, a thick, solid crust being then formed on the surface. During the frequent heavy rains in June and July, the soil became quite hard and compact; this was readily noticeable by the shape of the beets harvested, as many of the beets were forked and had grown abnormally thick and short. The field which lies in the western portion of the experimental plot grounds was divided into seven plots of one-twentieth of an acre each. Cereal and rape crops were grown on plats 1 to 5 during the previous two seasons, while the two plats furthest north (6 and 7) were in clover during these years. The field was in a high state of fertility; a medium application of barnyard manure was put on plats

1 to 5 in the fall of 1901 previous to plowing, while plots 6 and 7 were plowed about six inches deep in the spring of 1902.

In addition to barnyard manure, three of the plots received the following artificial fertilizers, viz.: Plat 4, 50 lbs. of Swift's Sugar Beet Grower, 29 lbs. of nitrate of soda, and 20 lbs. sulfate of potash. The commercial fertilizers were harrowed in directly before planting except in case of the nitrate, of which one-half was applied at planting-time and the other half when the beets were thinned.

The seed used, which was supplied by the U. S. Dept. of Agriculture, was Kleinwanzleben Nachzucht, from H. Bennecke, Athensleben, near Loderburg, Germany (U. S. Dept., No. 8238). The beet field was disked and harrowed on April 15, and again on April 24, when the seed bed was carefully prepared and the seed planted in rows 18 inches apart, at the rate of 20 lbs. to the acre. The field was harrowed lightly after the seed was put in. It was cultivated with a hand cultivator on May 8, 19, 22, and June 3d. The beets were hand-hoed on May 22d and June 20th, and thinned on May 26th, so that the plants stood approximately nine inches apart in the row. The field did not receive any further treatment after June 20th until harvesting time, except that all weeds were pulled by hand on July 21st. The stand of the beets was perfect and the field presented a fine appearance, the beets looking thrifty and strong throughout the growing period. Fig. 33 is a reproduction of the photograph of the beet field taken on June 22.

Owing to the abundance of moisture during the summer months and the cool weather during the months of August and September, the beets matured later than will ordinarily be the case in this locality. Samples of the beets grown on plot 4 were taken every week from September 14 on, at the request of Dr. H. W. Wiley, Chief of Bureau of Chemistry, U. S. Department of Agriculture. The beets in 50 ft. of row were dug and weighed before and after being washed, and three beets of average size taken for a sample in each case. The results of the weighings and analyses made on the different dates of sampling are shown in the following table:

TABLE 1.—*Analyses of sugar beets grown at University farm, season 1902.*

Date of Sampling.	Average weight	Sugar in juice.	Sugar in beet.	Purity.	Av. weight of beets dug.*	Weight of wash'd beets.	Weight of tops.	Estimated yield of wa'hed beets per acre.
	Lbs.	Pr. ct.	Pr. ct.	Pr. ct.	Lbs.	Lbs.	Lbs.	Tons.
Sept. 14.	1.03	14 44	13.29	78.6	1.5	101	59	30.0
Sept. 20.	1.17	14.80	13.16	79.3	1.6	94	59	27 3
Sept. 27.	1.58	13 97	12.85	83.3	1.8	120	....	34.8
Oct. 4	1 58	15.66	14 41	77.4	1.8	114	63	33 1
Oct. 11. (Harvest).....	1.26	13.77	12.67	81.0	....	....	....	29.7

* Cut off at top of the crown.

FIG. 33.—View of University beet field, June 22, 19[illegible].

Single analyses do not always give a correct indication of the maturity of the beets at the time of the sampling and the results should therefore not be interpreted too strictly. We notice but slight improvement in the sugar content or purity of the beets after the first sampling. In ordinary seasons, beets grown in this locality will be ready for harvesting during the first half of the month of September. The beets were har-

vested on October 11th; those grown on the different plots were of course kept separately, while those grown in the spaces between the plots were thrown together and sampled by themselves. (Plot 8 in the following table.)

The results obtained at harvesting time are shown below. As the loads of beets grown on each plot were weighed, a bushel-basket full was taken for determination of the tare. The percentage tare thus obtained for the different plots was as follows: 5.2, 5.8, 4.5, 12.5, 4.7, 7.4, 3.6, and 6.2 per cent. for plots 1 to 8, respectively. The determination of the tare in case of plot 4 seems abnormally high, but as the weights could not be verified at the time the results were figured out, it has been accepted as correct.

In the column headed Washed beets, in the following table, the percentage tares given have been deducted from the gross weights of beets harvested. A number of different samples were taken from the beets grown on the different plots, viz.: 3 to 4 in all, and subjected to examination by the polariscope method. The weights of beets given in the first column of the table refer to washed beets, topped below the lower leaf buds as is the general practice at sugar factories.

TABLE 2—*Analyses of sugar beets, University farm, 1902.*

Plot.	Average weight.	Sugar.		Purity coeff.	Yields of Washed Beets.		Sugar per acre.
		In juice.	In beet.*		Per plat.	Per acre.	
	Lbs.	Per cent	Per cent	Per cent.	Lbs.	Tons.	Lbs.
1	1.34	14.22	13.08	85 2	3,196	32.0	8,371
2	1.42	15.49	14.25	82.6	3,042	30.4	8,637
3	1.27	15.37	14.14	87.3	3,115	31 2	8,811
4	1.26	13.77	12.67	81.0	2,974	29.7	7,489
5	1.44	14.85	13.66	83.1	3,054	30.5	8,333
6	1.42	15.06	13.86	85.1	2,814	28.1	7,789
7	1.46	14.83	13.64	88.4	2,755	27.6	7,529
8	1.12	15.72	14.46	85.0	2,533	29.9	8,647
Average	**1.34**	**14.91**	**13.72**	**84.5**	**23,483**	**29.945**	**8,213**

* Factor, 92.

The most striking feature about the results presented in the preceding table is the large yield of beets harvested; more than 11 tons of washed beets were taken off the beet field, which covered an area of only about two-fifths of an acre; that is, a yield

at the rate of nearly 30 tons to the acre. This is an extraordinary yield, which has never been equaled in previous trials with sugar beets at this Station. The following summary statement shows the average yields obtained with beets grown at the University farm during the past twelve years. The detailed data for each year have been published in our annual reports, 8 to 17.

TABLE 3— *Yields of beets and sugar, University farm, 1890–1902.*

Season.	Beets per acre.	Sugar per acre.
	Tons.	Lbs.
1890	19.80	5,913
1891	7.34	2,267
1892	11.31	3,821
1897	9.13	2,503
1898	18.71	5,312
1899	18.83	5,805
1900	16.99	3,862
1901	10.97	2,623
1902	29.94	8,213
Average 1890-1902	**15.89**	**4,258**
Average 1890-1901	**14.14**	**3,764**

We notice that the average yield of beets per acre for eight seasons prior to 1902, during which sugar beets have been grown at our Station, is 14.14 tons and that of sugar 3,764 pounds. The yields of both beets and sugar obtained during the past season are therefore more than twice those obtained on the average during the preceding seasons when trials of sugar beets have been conducted by us; in no previous season has the yield of beets per acre reached two-thirds of this season's yield, and the yield of sugar per acre has never been more than three-fourths of that obtained this year.

The splendid showing this year is no doubt attributable to at least three causes: The abundant supply of moisture during the growing season; the high state of fertility of the soil on which the beets were planted, and the long vegetation period which they had. The seed was planted and the beets thinned nearly one month earlier than has been the practice at this Station in past years. While the beet field was not large, there would have been no difficulty in securing a similar yield per acre for as large an area as the help available at the University farm could take proper care of.

The expense of growing an acre of beets under ordinary conditions is generally estimated to be from $25.00 to $30.00. Beets of a similar quality as those grown at the University farm during the past season are paid for at the sugar factory, at Menomonee Falls, Wis., at the rate of $4.42 per ton. This would make the product from an acre worth $132.60, or there would be a net profit of upward $100.00 per acre. The expense of labor required to keep the field free from weeds was higher this year than during ordinary seasons, on account of the difficulty in getting onto the field at the right time after the many heavy rain storms during the early part of the summer.

The profit of growing an acre of beets with a yield like that secured by us during the past season would at all events be very large. The results of investigations conducted at this Station in the past have shown that even if the yield of beets should be only one-half of that obtained this year, the beet crop would still be a very profitable one for Wisconsin farmers to engage in if they are within a reasonable distance from a beet factory; estimating the value of the beets and the cost of growing them as above, there would still be a net profit in half of this season's crop of about $40.00 per acre of beets grown. It is believed there are few crops that can be grown in this state which will pay better during a series of years where proper attention is given to the crop, than is the case with sugar beets. As one sugar factory is now in operation in this state in its second season and one or two more factories will in all probability be erected in time for next season's crop, the farmers in many localities in our state will soon have an opportunity to engage in the growing of sugar beets for factory purposes. The practical importance of the subject will therefore be evident. A careful consideration of the data presented in this and the preceding reports from this Experiment Station on the subject of beet culture is earnestly recommended to those interested.

ANALYSES OF LICENSED FERTILIZERS AND FEEDING STUFFS, 1902.

F. W. WOLL AND GEO. A. OLSON.

A. Licensed Commercial Fertilizers, 1902.

The following manufacturers have taken out a license for the sale of the brands of fertilizers given, in this state during the current year, in accordance with Wisconsin statutes of 1898, sec. 1494c.

Station No.	Name of Manufacturer.	Name of Brand.
46	Armour Fertilizer Works, Chicago	Ammoniated Bone and Potash.
47	Armour Fertilizer Works, Chicago	Bone Meal.
48	Armour Fertilizer Works, Chicago	All Soluble.
49	Armour Fertilizer Works, Chicago	Grain Grower.
50	Milwaukee Tallow and Grease Co., Milwaukee, Wis	Milwaukee Tallow and Grease Co.'s Bone Meal.
51	Darling & Co., Chicago	Darling's Tobacco Special.
52	Darling & Co., Chicago	Darling's Chicago Brand.
53	Currie Bros., Milwaukee, Wis	Currie's Complete Fertilizer for Lawns, Hay and Pasture.
54	Swift & Co., Chicago	Swift's Superphosphate.
55	Packers' Fertilizer Association, Chicago	Boar's Head Brand, World of Good Superphosphate.
56	Packers' Fertilizer Association, Chicago	Boar's Head Brand, Potash Phosphate

The Station analyses of the brands given are shown in the following table. According to the state fertilizer law each manufacturer "shall affix to every package of fertilizer sold . . . a statement of the following fertilizing constituents, namely: The percentage of nitrogen in an available form, of potash soluble in water, and of available phosphoric acid, solu-

Analyses of licensed commercial fertilizers in Wisconsin, 1902.

Station No.	Name of Brand.	Moisture.	Nitrogen.*		Phosphoric Acid.						Potash.	
			Found.	Guaranteed	Soluble.	Reverted.	Available.		Total.		Found.	Guaranteed.
							Found.	Guaranteed.	Found.	Guaranteed.		
		Pr ct.	Pr ct.	Pr ct.	Pr ct.	Pr ct.	Pr ct.	Pr ct.	Pr ct	Pr ct.	Pr ct.	Pr ct,
46	Ammoniated Bone and Potash	7.84	2.[illegible]0	2.47	4 76	2.79	7.55	6.0	10.00	8.0	2 50	2.0
47	Bone Meal	4.90	4 10	2.49	....	....	....	....	24.58	24.0	....	....
48	All Soluble.	4.63	2.71	2.88	4.10	4.90	9.00	8.0	11 53	10.0	4.25	4.0
49	Grain Grower	3.85	1.99	1.65	7.47	4.73	12.20	8 0	13.36	10.0	3.08	2.0
50	Milwaukee Tallow and Grease Co's Bone Meal	5 00	4 20	4.0	....	....	....	....	22.26	20.0	....	....
51	Darling's Tobacco Special	5.00	3.36	3.29	4.68	2.64	7.32	7.0	11.91	9.0	7.89	7.0
52	Darling's Chicago Brand	5.95	1.82	1.64	4.44	4.10	8.54	8.0	10 57	10.0	2.11	2.0
53	Currie's Complete Fertilizer for Lawns, Hay, and Pasture	2.00	5.13	4 96	.50	2.78	3.28	....	12.70	14.55	7 88	7.04
54	Swift's Superphosphate	11.23	2.24	1.64	5.98	4 09	10.07	8.0	12.82	12.0	2.05	2.0
55	Boar's Head Brand, World of Good Superphosphate	6.51	2 06	2.05	8 00	.93	8.93	8 0	11 53	10.0	.30	1.5
56	Boar's Head Brand, Potash Phosphate	7.75	.14	....	9.33	....	9.33	10.0	10.24	12.0	5.13	4.0

* Soluble nitrogen: No. 46, .11 per cent.; No. 48, .34 per cent.; No. 49, .20 per cent.; No. 51, .78 per cent.; No. 52, .37 per cent.; No. 53, 3.05 per cent.; No. 54, 1.13 per cent.: No. 55, .40 per cent.

ble and reverted, as well as total phosphoric acid." The guaranteed composition of the licensed fertilizers is given in the table in connection with the results of our analyses of the samples furnished by the manufacturers in compliance with the law.

The mechanical analysis of the samples of bone meal included among the licensed brands of fertilizers gave the following results, the portion passing through a sieve of one-fiftieth inch mesh being designated as *fine-ground,* and that remaining on such a sieve as *coarse.*

Mechanical analysis of bone meal.

Station No.	Brand.	Fine-ground	Coarse.
		Per ct.	Per ct.
47	Bone Meal	59	41
50	Milwaukee Tallow and Grease Co.'s Bone meal	89	11

Fertilizer inspection.—It is impossible to tell from the appearance or odor of a commercial fertilizer whether it contains a large amount of valuable fertilizing ingredients or only a very small amount. There is therefore a strong temptation for irresponsible parties to make and sell inferior or even valueless goods as standard fertilizing articles; so much so, that it has been found necessary in all states where the fertilizer business has grown to be of any importance, that the state should in some way supervise their sale. Laws regulating the sale of commercial fertilizers are at present in force in a large majority of the states of the Union. The Wisconsin fertilizer law which was passed by the legislature in 1895 is given in full in the following pages. According to the provisions of the law, all commercial fertilizers sold in this state at a cost exceeding $10.00 per ton are to be licensed. They must be sold on a guarantee of certain amounts of valuable fertilizing ingredients contained therein, and the director of the experiment station, on whom is laid the duty of enforcing the law, is authorized, in person or by deputy, to take samples of all commercial fertilizers sold in this state which come within the scope of the law. In case of

licensed fertilizers it may thus be ascertained whether these come up to the guaranteed composition, and when it is found that parties are selling fertilizers without complying with the provisions of the law, the offenders may be brought before the proper legal authorities and convicted according to section 1494d of Wisconsin statutes of 1898. This section imposes a fine of $100.00 for the first offense and $200.00 for each subsequent offense.

It is hoped that all dealers in commercial fertilizers in the state will comply with the law in all particulars, and that they as well as purchasers of such fertilizers, will assist in the enforcement of the law by giving notice of violations of the same. A strict compliance with the law is for the best interests of all honest dealers and consumers alike. Only firms that live up to the requirements of the law and have taken out licenses for the sale of their brands of fertilizers should be patronized; the law does not offer purchasers any protection against dealers in other states who sell inferior or fraudulent goods.

B. Licensed Commercial Feeding Stuffs, 1902.

The Wisconsin feeding stuff law was passed by the state legislature in 1901 and went into effect on January 1st, 1902. In accordance with the provisions of the law twenty-three manufacturers or dealers have taken out licenses for the sale of forty different brands of concentrated feeding stuffs in this state for the calendar year ending Dec. 31st, 1902. The names and addresses of the manufacturers or dealers, the names of the licensed brands, and the guarantees of protein and fat for each brand, given by the manufacturers as required by the law, are shown in the following table:

Licensed commercial feeding stuffs, 1902.

	Name of Brand.	Manufacturer or Agent.	Guarantee. Protein.	Guarantee. Fat.
	OIL MEALS.		Pr. ct.	Pr. ct.
1	**Ground Linseed Cake, O. P**	Midland Linseed Oil Co., Minneapolis, Minn	32.5	5 5
2	**Ground Linseed Cake**	Wm. Goodrich & Co., Milwaukee, Wis	34.0	5.0
3	**Ground Linseed Cake**	American Linseed Co., Minneapolis, Minn	31.0	5.0
4	**Bannon's Guaranteed Pure Oil Meal**	Superior Linseed Oil Mills, West Superior, Wis	35 0	6.0
5	**Ground Oil Cake**	Northern Linseed Oil Co., Minneapolis, Minn	35.0	6 0
6	**Ground Linseed Cake**	Minnesota Linseed Oil Co., Ltd. Minneapolis, Minn	31.0	5.0
7	**Cottonseed Meal**	N. K. Fairbank Co., Chicago	43.0	9.0
	GLUTEN MEALS AND FEEDS, CORN FEEDS, ETC.			
8	**Chicago Gluten Meal**	Glucose Sugar Refining Co., Chicago	38.0	4.0
9	**Buffalo Gluten Feed**	Glucose Sugar Refining Co., Chicago	28 0	4.0
10	**Germ Oil Meal**	Glucose Sugar Refining Co., Chicago	25.0	10 0
11	**Fancy Corn Bran**	Glucose Sugar Refining Co, Chicago.	14.0	4.0
12	**Waukegan Gluten Feed**	U. S. Sugar Refinery, Chicago	27.38	3.39
13	**Atlas Gluten Meal**	Atlas Feed and Milling Co., Peoria, Ill	35 0	12.5
14	**Hominy Feed**	Meurer, Deutsch & Sickert Co., Milwaukee, Wis	11.0	7.0
15	**Great Western Hominy Feed**	Great Western Cereal Co., Chicago	12.16	7.72
16	**Star Hominy Feed**	E. P. Mueller, Milwaukee, Wis	9 9	8.5
	MIXED CORN AND OAT FEEDS.			
17	**Victor Corn and Oat, or C Feed.**	American Cereal Co., Chicago	9.0	4.0
18	**Quaker Dairy Feed**	American Cereal Co., Chicago	14.0	3.5
19	**Great Western Dairy Feed**	Great Western Cereal Co., Chicago	12 25	3.20
20	**Excelsior Corn and Oat Feed**	Great Western Cereal Co., Chicago	8.20	4 58
21	**Royal Oat Feed**	Great Western Cereal Co., Chicago	8.25	4.14
22	**Boss Corn and Oat Feed**	Great Western Cereal Co., Chicago	8.27	3.65
23	**Cream Oat Feed**	Great Western Cereal Co., Chicago	6 97	2.83
24	**Imperial Corn and Oat Feed**	Meurer, Deutsch & Sickert Co., Milwaukee, Wis	12.0	4.0
25	**Hominy Mixed Feed**	Peter Schmitz & Son, Milwaukee, Wis	9.05	5.66
26	**Ne Plus Ultra Mixed Feed**	Wm. Kaul, Milwaukee, Wis	11.36	4.74
	MISCELLANEOUS DAIRY FEEDS.			
27	**Blatchford's Calf Meal**	John W. Barwell, Waukegan, Ill.	26.0	5.0
28	**Sucrene Dairy Feed**	American Milling Co, Chicago	16.5	3.5
29	**Badger Brand Dried Grains**	E. P. Mueller, Milwaukee, Wis	24.86	5.69
30	**Gee's Germ Middlings**	Meurer, Deutsch & Sickert Co., Milwaukee, Wis	14.98	6.64
31	**Blatchford's Sugar and Flax Seed**	John W. Barwell, Waukegan, Ill.	28.31	11.26
32	**Biles' XXXX Distillers' Dried Grains**	The J.W. Biles Co., Cincinnati, O.	33.0	11.0

Licensed commercial feeding stuffs, 1902 — Continued.

	Name of Brand.	Manufacturer or Agent.	GUARANTEE.	
			Protein.	Fat.
	POULTRY FOODS.		Pr. ct.	Pr.ct.
33	**Blood Meal**	Armour Fertilizer Works, Chicago	85.0	2.0
34	**Swift's Blood Meal**	Swift & Co., Chicago	87.5	2.39
35	**Swift's Pure Tankage, Specially Prepared**	Swift & Co., Chicago	60.0	12.0
36	**Darling's Beef Meal**	Darling & Co., Chicago	55.0	10.0
37	**Meat Meal**	Armour Fertilizer Works, Chicago	65.0	12.0
38	**Blatchford's Poultry Meats**	John W. Barwell, Waukegan, Ill.	33.0	10.0
39	**Granulated Poultry Bone**	Armour Fertilizer Works, Chicago	24.0	5.0
40	**Chamberlain's Perfect Chick Feed**	W. F. Chamberlain, St. Louis, Mo	11.81	2.87

Samples of concentrated commercial feeding stuffs offered for sale in the state under the provisions of the law were taken by representatives of the Station, during the past year, and nearly all of these samples have been analyzed in our chemical laboratory. The inspection of the feed stores and the sampling of the feeding stuffs during the past year have been made by J. D. Clarke, of Milton, Wis., Roscoe H. Shaw, late acting chemist of this Station, Roy T. Harris, of Warrens, Wis., and the writer (W.).

The inspections were begun on January 2, 1902, and have been continued with intervals throughout the year up to the present time (Nov. 1st). Seven hundred thirty-eight feed dealers in 171 different towns and cities in the state were visited and 597 samples of concentrated feed stuffs were taken in all. In addition to these samples taken by our feed inspectors, 72 samples were forwarded direct to the Station for examination by dealers or farmers, most of which have also been analyzed.

More than one-half of the concentrated feeds sold in this state are most likely flour-mill refuse feeds, wheat bran and wheat middlings or shorts. These feeds are exempt from license, according to sec. 1 of our feeding stuff law; it was deemed desirable, however, to procure samples of the output of as many dif-

ferent flour mills disposing of their by-products in this state as possible, so as to be able to judge of the variations in quality to which these feeds are subject and to ascertain whether or not the bran or middlings offered for sale in our state are pure, unadulterated goods. In all 281 samples of wheat bran, middlings, shorts and red dog were thus collected, and such of these feeds as represent the output of different mills were subjected to chemical analysis for moisture, protein and fat.

The following list gives a summary of the number of samples of concentrated feeding stuffs, collected under our state feeding stuff law or received from outside parties up to November 1st, 1902:

List of samples of concentrated feeding stuffs collected or forwarded for examination, season 1902.

Name of Feeding Stuff.	Samples collected.	Samples forwarded for examination.	Total.
Oil meals or cotton-seed meal	60	10	70
Gluten meals or feed, hominy feeds	14	8	23
Licensed corn, or corn and oats feed	36	15	51
Ground corn and oats (sold as pure)	81	....	81
Wheat bran	159	14	173
Wheat middlings or shorts	115	3	118
Rye bran	4	....	4
Rye middlings or shorts	4	....	4
Other millers' or brewers' refuse feeds:			
Wheat	53	4	57
Corn	10	1	11
Oats	3	3	3
Barley	5	1	6
Rye	7	....	7
Buckwheat	5	....	5
Rice	....	2	2
Miscellaneous licensed dairy feeds	25	6	31
Miscellaneous unlicensed feeding stuffs	1	4	5
Poultry foods	12	....	12
Stock foods	6	....	6
Total	597	72	669

The analysis of the samples of licensed commercial feeding stuffs collected by us or furnished by the manufacturers during the present year are shown in the tables on pp. 8–12 of bulletin No. 97 of this Station, which also contains tables showing the analyses of a number of samples of different feeds coming under the feeding stuff law which had not, for various reasons, been licensed for sale in this state, as well as analyses of feeds that are not subject to license under the law.

SUMMARY OF ANALYSES OF LICENSED FEEDS.

The following table gives a summary of the results of the chemical analysis of the samples of licensed feeding stuffs collected during the present year. The samples furnished by the manufacturers, in registering their various brands for license, are not, as a rule, included in this summary. The reader is referred to bulletin No. 97 for information as to the origin of the samples analyzed and for discussions of the results of these and other analyses made in the feed inspection work during the past season.

Summary of analyses of licensed feeds, 1902.

	No. of analyses.	Moisture.	Protein		Fat		Crude fiber.
			Guaranteed.	Found.	Guaranteed.	Found.	
		Pr ct.		Pr ct.	Per ct.	Pr ct.	Pr ct.
Oil Meal:							
Midland Linseed Oil Co	9	7.87	32.0-32.5	30.18	5.5	8.57	......
Wm. Goodrich & Co	2	6 18	34.0	36 62	5.0	7.56	......
Am. Linseed Co	5	8.20	34.0	38.93	5 0	8.03	......
Superior Linseed Oil Mills	1	8.17	35.0	34.93	6.0	12.45	......
Northern Linseed Oil Co	3	8.98	35.0-37.46	35.15	6.0-8.65	7.40	......
Minn. Linseed Oil Co	2	6.47	34 0	35.92	5 0	8.77	......
Cotton Seed Meal: N.K.FairbankCo	1*	4.75	43.0	43.56	9.0	9.63	6.87
Chicago Gluten Meal	4	6.91	38 0-39.0	35.62	2.0-4.0	3.11	......
Buffalo Gluten Feed	4	8.49	27.0-28 0	26.32	3.0-4 0	2 84	8 65
Germ Oil Meal	1*	6.63	25.0	23.72	10.0	9.97	......
Fancy Corn Bran	1*	5.64	14.0	13 57	4.0	2 59	14.83
Waukegan Gluten Feed	2	7.60	27.38	24.84	3 39	3 27	10.63
Atlas Gluten Meal	1	5.68	35.0-36.00	35.53	11 5-12.5	11.68	17.33
Hominy Feeds:							
Meurer, Deutsch & Sickert Co	3	7.36	11.0	11 13	7 0	8.98	4.47
Great Western Cereal Co	2	8 32	12.16	11.53	7 72	7.07	5.34
Star Hominy Feed	1	14.26	9.9	11.60	8.5	6 23	3.77
Victor Corn & Oat Feed	5	9.09	8 23-9 0	8.81	3.0-4.0	3.31	11.38
Great Western Cereal Feed	2	5.44	12.25	9.59	3.20	2.67	27.91
Excelsior Corn & Oat Feed	6	8.81	8.2-9.35	9.55	4.58-4.8	4 98	13.08
Royal Oat Feed	1	5.35	7.53	8.95	2.65	2.33	31.20
Imperial Corn & Oat Feed	3	8 24	12.25	11.33	4.08	4.15	13.13
Quaker Dairy Feed	1	6.13	13.0	17.44	3.75	3.50	19.65
Boss Corn & Oat Feed	2	8.42	7.94-8.27	10.86	3.65-4.19	3.17	14.64
Cream Oat Feed	1	6.23	6.97	7.28	2.33	2.25	32.67
Hominy Mixed Feed	2	7.37	9.05	9.80	5.66	7.07	10.33
Ne Plus Ultra Mixed Feed	1	7.60	11.36	8.86	4.74	2 36	14.35
Blatchford's Calf Meal	2	9.47	26.0	26.94	5.0	4.76	......
Blatchford's Sugar & Flax Seed	2	8.52	28.25-28.31	30.60	11.25-11.26	10.17	......
Sucrene Dairy Feed	2	7.80	16 50	20.32	3.50	1.29	14.82
Badger Brand Dried Grains	1*	3.36	24.86	24.86	5.69	5.69	12 23
Gee's Germ Middlings	2	11.33	14.98	14.37	6.64	5 50	12.14
Biles' XXXX Distil'rs' Dried Grains	1*	4.79	33.0	32 43	11.0	10.82	8.85
Granulated Poultry Bone	1*	6.53	24.0	23.95	5.0	.90	......
Armour's Blood Meal	1	7.96	85.0	85.12	2.0	.25	......
Swift's Blood Meal	1	7.74	87.5	83.36	2.70	.28	......
Armour's Meat Meal	1*	6.63	65.0	62.90	12.0	18.10	......
Swift's Pure Tankage	1*	2.92	60.0	60.19	12 0	17.47	......
Darling's Beef Meal	2	6.18	55.0	61.36	10.0	9.13	......
Blatchford's Poultry Meats	2	6.11	33.0	37.93	10.0	9 68	......
Chamberlain's Perfect Chick Feed	1*	8.07	11.81	11.81	2.87	2.87	......

* Manufacturer's sample.

ANALYSES OF FLOUR MILL REFUSE FEEDS.

The following table gives the average results of our analyses of wheat bran, middlings, shorts and low-grade flour (*red dog*) during the past season, with the minimum and maximum percentages found in each case.

Analyses of Wisconsin flour mill refuse feeds.

	No. of samples.	MOISTURE.		PROTEIN.		FAT.	
		Av'age.	Range.	Av'age.	Range.	Av'age.	Range.
		Pr ct.	Per ct.	Pr ct.	Per ct.	Pr ct.	Per ct.
Wheat bran.......	147	9.50	6.41-16.01	16.57	13.57-20.48	4.49	2.97-6 32
Wheat middlings.	58	8.27	4.10-16.58	19.01	13.78-22.37	5.40	2.76-6.73
Wheat shorts.....	34	8 30	5.33-11.90	18.09	14.35-21 76	5.51	3 09-6.56
Red dog	7	8.00	5.[illegible]3-10.93	19.44	17.50-22.13	4.74	2.98-5.84

As a general rule, chemical analysis and microscopic examination showed these feeds to be of superior quality, and free from adulteration of any kind, except in case of the output of a few mills which was found to contain admixtures of either ground or whole wheat screenings. Wheat bran or other mill refuse feeds to which screenings have been added, can not be sold as pure wheat bran, middlings, etc., under our state feeding stuff law, and if so sold, the dealer will be liable under sec. 7 of the law.

ANALYSES OF GROUND CORN AND OATS.

The pure grains, ground together, are exempt from the provisions of the state feeding stuff law; in order to know, however, whether feeds sold as *ground corn and oats, mixed feed, chopped feed, ground feed,* etc., are composed of nothing but pure grains, it is necessary to subject samples of feeds of this class found on the market to chemical analysis. This was done during the past season when 96 samples of corn and oat feeds were collected and analyzed, nearly all of which were supposed to be composed of nothing but shelled corn and oats ground to-

gether and were sold as such. The detailed results of the analyses are given in our Bulletin No. 97.

Of the 96 samples analyzed during the past season, 33 samples are considered suspicious from the fact that they contained more than 7 per cent. crude fiber, and 18 samples are believed to be adulterated, having a crude fiber content of 9 per cent. or more. To either of these figures should be added the number of samples which had been adulterated with whole or ground screenings, and we then find that *38 per cent.* of the samples of corn and oats sampled and analyzed in our laboratory during the past season were suspicious, and *24 per cent.* were in all probability adulterated.

The extreme determinations of the samples analyzed came as shown in the following table:

Range in analyses of ground corn and oats, sold as pure.

	Moisture.	Protein.	Fat.	Crude fiber.
Minimum.	6.32 pr ct.	8.55 pr ct.	.70 pr ct.	2.95 pr ct.
Maximum	15.48 pr ct.	14.74 pr ct.	5.88 pr ct.	24.20 pr ct.

The materials used for adulterating corn and oat feeds are low-grade refuse products like oat hulls, oat dust, crushed corn cobs, corn bran, and mixed corn and oat feeds composed largely of such refuse materials. Victor Corn & Oat Feed ("C" Feed) is thus known to have been used for the purpose of adulterating ground corn and oats. These adulterations, and the sale of mixed corn and oat feeds as pure ground grains, form the most serious violation of our state feeding stuff law. Other adulterations that have been established during the past season are the admixture of ground or whole screenings to mill refuse feeds, oat feeds, and ground corn and oats, and of Marsden feed (ground corn pith) to dried brewers' grains. Aside from the adulteration of the grain feeds, the situation in this state is not, on the whole, discouraging, however, and with the co-operation of dealers and consumers we hope to improve, so that spurious goods shall not be able to find a market inside the borders of our state. We are pleased to note that our experience dur-

ing the past year has taught us that, with but a very few exceptions, the sentiment among feed dealers in this state is heartily in favor of the law; they, as well as purchasers of concentrated feeding stuffs, can be counted on to assist in the enforcement of the law, by refusing to handle or buy adulterated goods, and by informing us of adulterations or suspicious cases that may come to their attention.

The Wisconsin feeding stuff law which is given in full at the close of this report, provides that the following concentrated feeding stuffs shall be subject to examination and license under the law:

Linseed meal.
Cottonseed meal.
Oil meals of all kinds.
Peameal.
Cocoanut meal.
Sucrene feed.
Hominy feed.
Rice meal.
Mixed feeds of all kinds (unless made up of foods not subject to license, when branded so as to show their true composition).
Gluten meal.
Gluten feed.
Maize feed.
Starch feed.
Sugar feed.
Cerealine feed.
Oat feed.
Corn and oat feed.
Ground beef.
Dried blood.
Fish scrap.
Poultry foods (except such composed exclusively of inorganic materials, like oyster shells, quartz grit, etc.).
Condimental stock foods (claimed to possess nutritive as well as medicinal properties).

Application blanks for registering brands of concentrated feeding stuffs for sale in this state under the state feeding stuff law will be forwarded upon request. A license certificate will be issued on receipt of the blanks properly filled out, accompanied by the license fee of $25.00 for each feeding stuff bearing a distinguishing name, and a two-pound analysis sample of the brand to be licensed.

The law provides that all licensed goods must be sold under guarantee of their contents of protein and fat; if sold in bags the following information must be *plainly stenciled on each bag:*

The name of the feed and the number of net pounds thereof in the bag,

The name and address of the manufacturer, and

The guaranteed percentages of protein and fat.

If sold in bulk, a printed statement giving similar information must be furnished with each car or other amount sold, and a certified copy of this statement shall be supplied to purchasers upon request.

Manufacturers are asked to promptly inform the Station of any change in the guarantee for the protein and fat contents of licensed goods that it may be found necessary to make during the year, so that the guarantees may be correctly given on our books and in future publications.

All feed dealers handling goods that come under the provisions of the law should see to it that these are licensed for sale in this state and that the packages in which they are sold are plainly marked on the bags as described above. Dealers are liable under the law if they handle goods that are not licensed for sale in this state or are not put up in accordance with the provisions of the law, and they should not accept such goods. They are requested to report all delinquencies to the Director of this Station and to forward samples of feeds that are suspected of being adulterated or below grade to the Station for examination. Description blanks and directions for taking samples will be furnished upon request and samples properly taken and forwarded to this Station will be examined or analyzed, if necessary, to the extent which the work on hand will permit, without expense to the party seeking the information. The Station reserves the right to publish all results thus obtained, with full information as to the history of the samples, in its bulletins and annual reports.

FOURTH REPORT ON EXPERIMENT IN PINCHING RASPBERRY SHOOTS.

F. CRANEFIELD.

Many growers of raspberries practice pinching the tips of the growing shoots to induce branching; others do not pinch them, believing that better results are obtained by allowing a natural development of the canes. The development of raspberry canes under the different methods of treatment is shown in the following illustration: The upper portion of Fig. 34 shows a cane which was allowed to develop in a normal manner, the middle portion a cane developed from a shoot pinched when about two feet in height resulting in the growth of laterals, and the lower cane pinched as No. 2 and the laterals pinched as they attained a length of 12 inches, producing a compact and bushy growth. All are from photographs of Gregg raspberry plants.

Five years since, eighteen rows of raspberries, each 150 feet long, were planted on the Station grounds for the purpose of studying the influence of pinching on the production of fruit and the growth of shoots and suckers.

The plan of the experiment as given in the Eighteenth Annual Report of this Station is here repeated:

"For the experiment, the plat of each variety was divided into three smaller plats, each of which contained three rows. Each of these three-row plats had one row that was left unpinched, one row of which the shoots only were pinched, and one row in which both the shoots and laterals were pinched. In the first plat of each variety, the shoots of the pinched rows were pinched as fast as they attained the height of 12 inches;

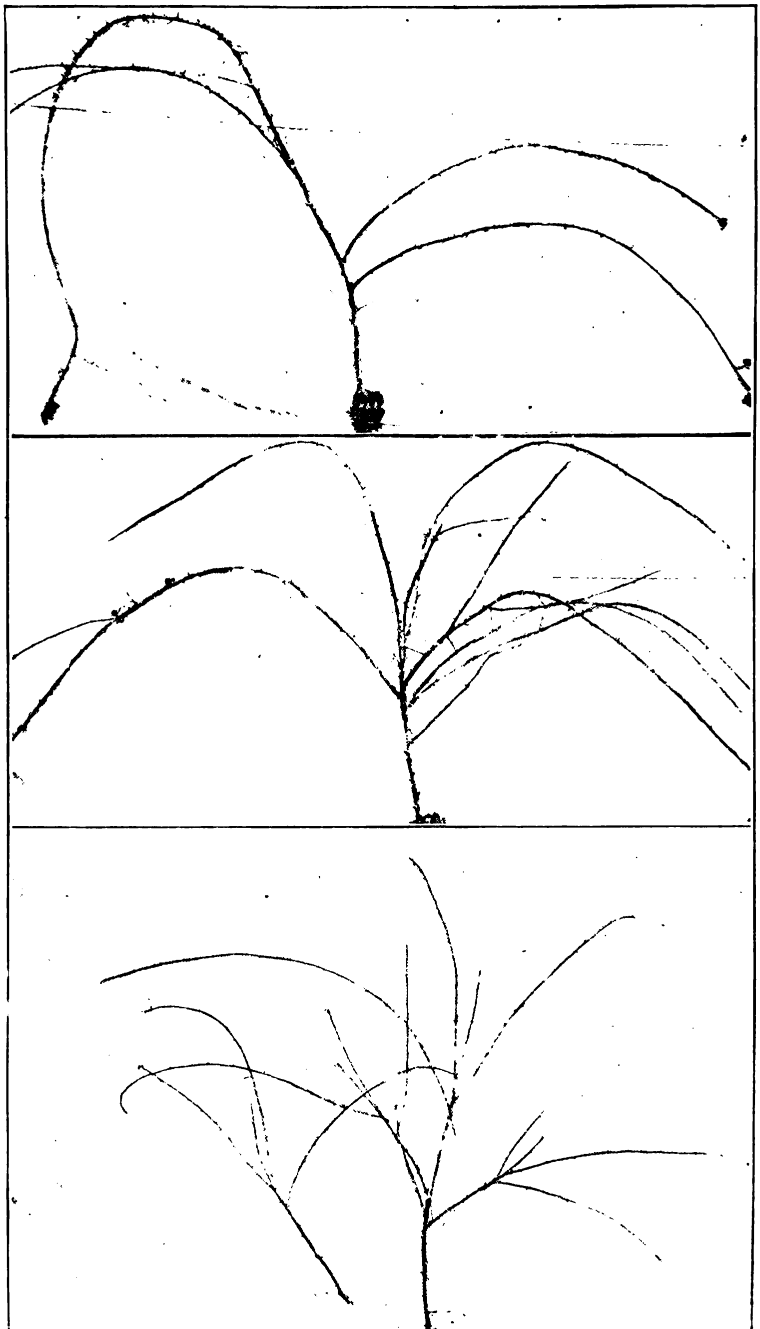

FIG. 34.—Showing branching of Gregg raspberry canes. Upper not pinched, middle pinched once, lower pinched twice.

in the second plat they were pinched as fast as they attained the height of 18 inches; and in the third plat, as they attained the height of 24 inches. The laterals were pinched as they attained a length of 12 inches."

Five shoots to a plant were allowed to grow and the plantation received ordinary care in cultivation, pruning, etc.

The plants have all been covered with earth each year for winter protection. Each plant was carefully examined from time to time during the growing season and the tips of the growing shoots removed as they attained the required height. The actual height attained by the pinched canes has usually exceeded that indicated in the outline of the experiment, viz., 12, 18, and 24 inches, by 3 to 4 inches, owing to the elongation of the internodes after the removal of the terminal buds.

After the required number of canes had been pinched in the rows selected for pinching, all superfluous shoots in the Gregg and suckers in the Cuthbert, were removed from all of the rows and weighed. By this means the influence of pinching on the production of shoots and suckers could be observed. There were originally 36 plants set in each row, but in several rows diseased plants have been removed, while in other rows the number has been increased by renewal.

In the following table is shown the number of bearing plants in each row the past season, the actual yield of fruit, the yield calculated to 36 plants per row and the average yield for four seasons.

Table showing effect of pinching the shoots on the yield of fruit.

	No. of plants.	Actual yield 1902.	Yield calculated to 36 plants per row, 1902.	Average of 4 seasons.
Gregg		Ounces.	Ounces.	Ounces.
Shoots not pinched	36	446 8	446.8	954.7
Shoots pinched at 12 inches	32	362.3	407.5	795.1
Shoots pinched at 12 inches – laterals at 12 inches	36	1000.9	1000.9	1118 7
Shoots not pinched	36	402.5	402.5	814.1
Shoots pinched at 18 inches	36	560.6	560.6	1150.8
Shoots pinched at 18 inches – laterals at 12 inches	37	505 5	491 8	1046.6
Shoots not pinched	34	427.7	452.5	952.8
Shoots pinched at 24 inches	37	516 8	502.5	1261.4
Shoots pinched at 24 inches – laterals at 12 inches	36	592.8	502.8	1182.4
Cuthbert.				
Shoots net pinched	36	397.4	397.4	970 2
Shoots pinched at 12 inches	33	319.8	347.7	830.5
Shoots pinched at 12 inches – laterals at 12 inches	36	408.7	408.7	857.7
Shoots not pinched	37	542 9	527.0	996.4
Shoots pinched at 18 inches	36	419 0	419.0	864.7
Shoots pinched at 18 inches – laterals at 12 inches	35	403.5	415.8	908.3
Shoots not pinched	34	794.7	841.3	773 4
Shoots pinched at 24 inches	34	708.8	750 2	992.9
Shoots pinched at 24 inches – laterals at 12 inches	32	585.5	658.4	773.7

This shows that the largest yield in the Gregg was from the row pinched once at 24 inches. The average yield from the rows pinched once was 1,069.1 ounces, and from the three rows pinched twice was 1115.8 ounces.

By taking the average of the high-pinched and low-pinched rows, we have the following: Two rows pinched at 12 inches, 956.9 ounces; two rows at 18 inches, 982.4 ounces; two rows at 24 inches, 1,221.9 ounces.

From this it would appear that the yield of the Gregg raspberry has been increased by pinching; that the rows pinched twice gave an increased yield over the ones pinched once; and that high pinching has given better results than low pinching.

In the Cuthbert, the three rows not pinched yielded an average of 913.3 ounces, the once-pinched 896.0 ounces, and the twice-pinched 846.5 ounces. Averaging the yield of the rows pinched at 12 inches, we have 844.1 ounces; of the two

at 18 inches, 886.5 ounces, and of the two at 24 inches, 883.3 ounces.

This would seem to show that pinching the growing shoots of the Cuthbert has decreased the yield of fruit, and that twice pinching is more injurious than pinching once. It will be seen also that the plants pinched at 18 and at 24 inches yielded more than those pinched at 12 inches. The largest yield was from a row not pinched.

Effect of pinching on the growth of shoots and suckers.— From the beginning of the experiment it was observed that the pinching affected the production of shoots and suckers. In the following table is given the weight in ounces of the shoots and suckers removed from the different rows during the past season, as well as the average for four seasons:

Table showing the effect of pinching on the growth of superfluous shoots and suckers.

Gregg.	1902.			Average four seasons.		
	Pinched twice.	Pinched once.	Not pinched.	Pinched twice.	Pinched once.	Not pinched.
Pinched at 12 inches	557.0	281.2	367.5	1051.7	686.6	851.0
Pinched at 18 inches	327.7	282.7	257.2	824.6	711.0	739.9
Pinched at 24 inches	274.2	212.0	242.0	883.2	658.0	434.9
Average	386.3	268.6+	288.9	919.8+	685.2	675.2
Cuthbert.						
Pinched at 12 inches	327.5	216.5	209.0	1703.0	1726.0	1492.4
Pinched at 18 inches	320.5	359.0	384.5	1764.7	1978.7	1713.4
Pinched at 24 inches	313.5	263.5	407.2	1333.1	1509.4	1828.2
Average................	320.5	279.6+	333.5+	1600.2	1738.0	1678.0

An examination of this table will show that pinching has increased the production of shoots in the Gregg and decreased the production of suckers in the Cuthbert.

Effect of pinching on the size of the berries.—At different times during the fruiting season 100 berries of average size were taken from each row and weighed on a delicate (torsion) balance in order to learn the influence of pinching on the size of the berries. In the following table is shown the average weight of the samples for the past two seasons, the weight being expressed in grammes.

Table showing the effect of pinching on the size of the berries.

	AVERAGE OF TWO SEASONS, 1901 AND 1902.					
	Gregg.			*Cuthbert.*		
	Pinched twice.	Pinched once.	Not pinched.	Pinched twice.	Pinched once.	Not pinched.
	Gramm's	Gramm's	Gramm's	Gramm's	Gramm's	Gramm's
Pinched at 12 inches	139.3+	120 6+	123.2	123 5	120.2	123.0
Pinched at 18 inches	121.0	122.4	124 0	117.0	125.6	136.2
Pinched at 21 inches	1 5 7+	126.2+	127.9+	138.4+	138.4	138.1
Average....	129 6+	123.0+	125.0	126 3	125.0	132.4+

It may be seen there is but little difference in the Gregg in the size of the berries from the high and from the low-pinched rows. The average weight of the samples from the three rows not pinched is less than that from the three rows pinched once, and this is less than from the twice-pinched rows. This would seem to show that pinching increases the size of the berries. This, however, is not in accordance with the results obtained the two years previous to 1901.*

In the Cuthbert the size of the berries appears to have been reduced by pinching.

The difference in appearance of the rows treated in the different ways is not conspicuous, as is shown by the accompanying illustrations, which are from photographs of a portion of the Gregg plat: Fig. 35 shows three rows as they appeared in April before growth had commenced, and Fig. 36 the same rows October 8th. The once-pinched rows spread fully as much as the ones not pinched, while the twice-pinched are a trifle more compact.

*Seventeenth Annual Report, Wis. Exp. Sta., p. 288.

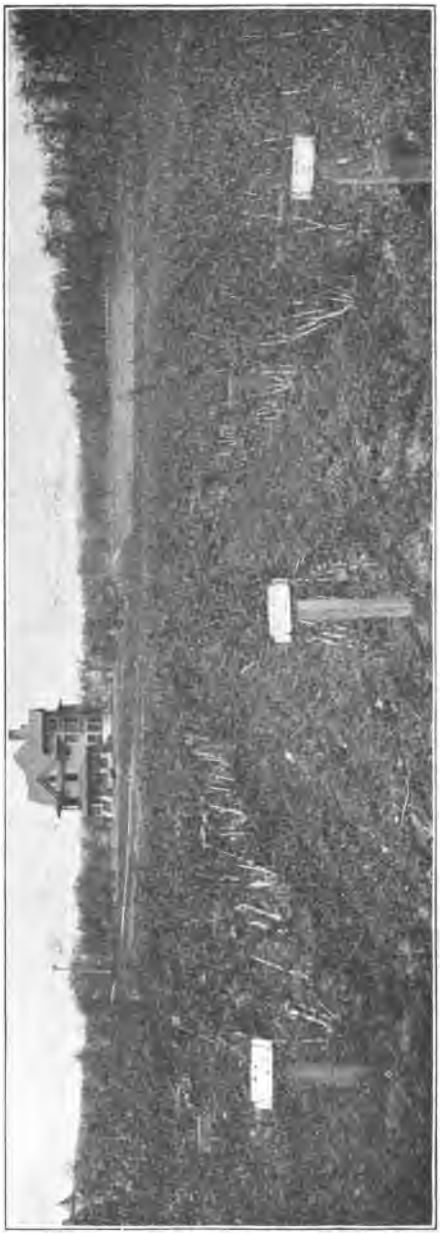

FIG. 35.—Showing Gregg raspberry plants in April. Left row not pinched, middle pinched once, right pinched twice.

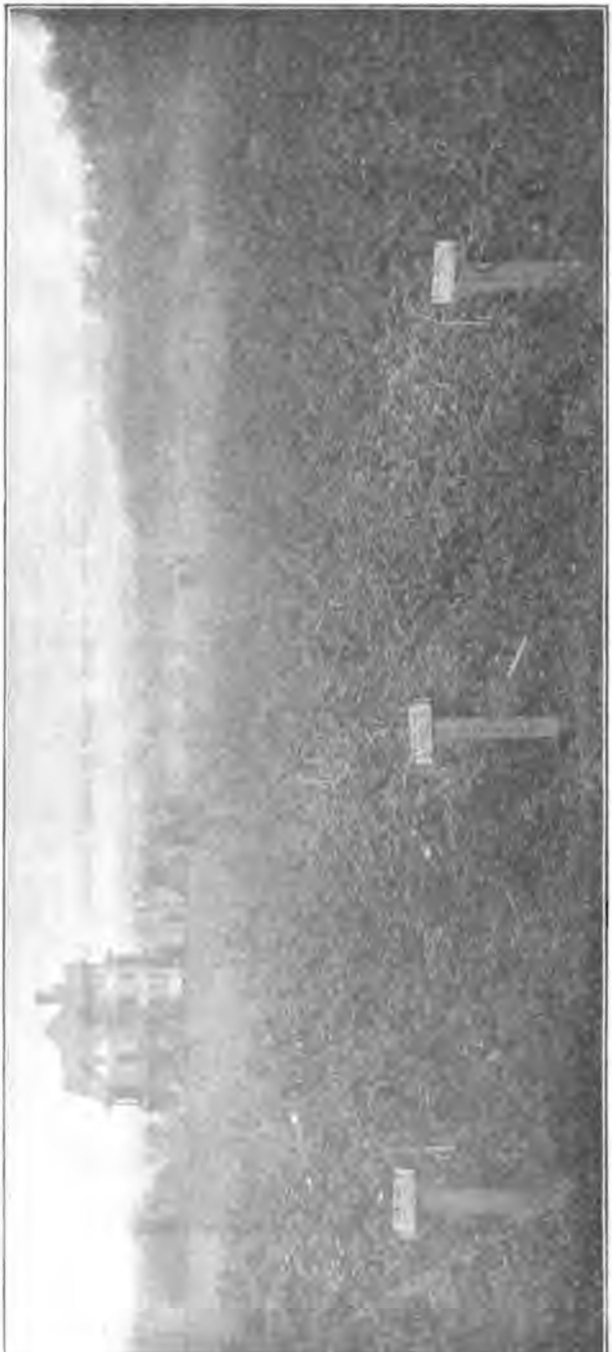

FIG. 36.—Same rows as Fig. 35, photographed Oct. 8.

SUMMARY.

From the data here given covering a period of four years the following conclusions seem justified:

The yield of the Gregg raspberry has been increased by pinching the growing shoots at 18 and at 24 incres. Pinching at 12 inches has diminished the yield of fruit.

The production of shoots has been increased by pinching.

Pinching has diminished the yield of fruit in the Cuthbert; twice pinching is more injurious than once pinching; high pinching caused less injury than low pinching. Pinching has decreased the production of suckers. The experiment will probably be continued one year longer.

THE INFLUENCE OF FORMALDEHYDE ON THE GERMINATION OF OATS.

F. CRANEFIELD.

In the last report of this Station is published an account of experiments dealing with the influence of formaldehyde on the germination of oats. In the experiments there noted a portion of the seeds was soaked for twenty minutes in a solution composed of 2½ parts of formaldehyde to 1,000 of water (1 pint to 50 gallons). This method of treatment is recommended for treating seed oats to prevent smut.

In order to study further the influence of formaldehyde on the viability of the seed, stronger solutions were also used and varying periods of time employed.

A comparison of the data obtained resulted in the following conclusions.*

"The experiments described above, covering the germination of over 25,000 seeds, lead to the conclusion that a formaldehyde solution as weak as 2½ parts to 1,000 may injure oats for seed; that in the case of the varieties tested the injury increased as the strength of the solution was increased;......that the growth of the plants appears to be checked at first as a result of treating the seed, but at the end of thirty days the plants from the treated seed very nearly equaled in height those from the untreated seed."

Seed testers were mainly employed in conducting the tests, but in a few cases the seeds were planted in shallow boxes of soil in the green-house.

*18th Annual Report, p. 334.

During the past season the work has been continued under field conditions, as follows:

First trial.—Two varieties of oats were selected, numbered for the purpose of the experiment as No. 1 and No. 4. The seed used was all of the crop of 1901. A portion of the seed of each variety was divided into three parts, one part being treated with formaldehyde, in the proportion of 2½ parts to 1,000 of water, for twenty minutes, one part soaked in water an equal length of time, and one part untreated.

On May 5th, three days after treating the seed, 1,000 seeds of each lot were planted in rows six inches apart, the seed one inch apart in the row and all covered evenly, one inch in depth. On May 15th and again on May 22nd the plants that had appeared were counted as follows:

Table showing the percentage of germination after ten and fifteen days respectively.

	No. 1.			No. 4.		
	No. of germinations after 10 days.	No. of germinations after 15 days.	Percentage of germinations after 15 days.	No. of germinations after 10 days.	No. of germinations after 15 days.	Percentage of germinations after 15 days.
Treated: 2¼ parts formaldehyde to 1,000 of water..	759	767	Per cent. 76.7	394	460	Per cent. 46
Untreated	833	833	83.3	483	535	53.5
Soaked in water.............	810	952	95.2	514	521	52.1

Comparing the results from the treated and untreated samples it appears that the percentage of injury arising from the treatment amounts to 6.6 per cent. in No. 1 and 6.5 in No. 4.

The seeds that were soaked in water for twenty minutes and allowed to dry for three days show a higher percentage of germination than either the treated or the untreated seed in No. 1 and a trifle lower percentage in No. 4.

The height of 100 plants was noted in each of the treated and untreated plots on May 15th and again on May 22nd. The average height of the plants in the different lots is shown in the following table the measurements being expressed in millimeters. (A millimeter is equal to about 1–25 of an inch.)

Table showing the average height in millimeters of 100 plants from treated and untreated seed after 10 and 17 days, respectively.

	No. 1.		No. 4.	
	Average height after 10 days.	Average height after 17 days.	Average height after 10 days.	Average height after 17 days.
	mm.	mm.	mm.	mm.
Treated	37.73	97.1	24.35	83.37
Untreated	41.05	103.05	29 38	81.44

An examination of these figures shows that the plants of both varieties of oats from the untreated seed made a greater growth during the first 10 days than the ones from the treated seed, but at the end of 17 days the plants from the untreated seed in No. 1 had outgrown those from the treated seed by an average of nearly 6 millimeters, while in No. 4 the untreated lot had fallen behind an average of nearly two millimeters.

Second trial.—In the second trial three varieties of oats were used, viz., Nos. 1 and 4, as in the first trial, and No. 22. For treating the seed four solutions of formaldehyde in water were prepared as follows:

One pint of formaldehyde to 50 gallons of water.
One pint of formaldehyde to 40 gallons of water.
One pint of formaldehyde to 25 gallons of water.
One pint of formaldehyde to 10 gallons of water.

A portion of seed of each of the varieties was soaked for twenty minutes in each of the solutions and after drying twenty-four hours 1,000 seeds of each lot were planted as in the first experiment. In each case 1,000 untreated seeds were planted for comparison.

The number of germinations after 10 and 17 days is shown in the following table.

Table showing the number of germinations of treated and untreated seed after 10 and 17 days respectively.

	No. 1.		No. 4.		No. 22.	
	No. of germinations after 10 days.	No. of germinations after 17 days.	No. of germinations after 10 days.	No. of germinations after 17 days.	No. of germinations after 10 days.	No. of germinations after 17 days.
Untreated	787	836	379	454	619	709
Treated: one pint formaldehyde to 50 gal. water	522	719	177	322	439	535
One pint to 40 gal	527	683	185	312	459	529
One pint to 25 gal	421	622	75	242	281	421
One pint to 10 gal	81	276	22	136	136	233

The results in this trial are similar to those obtained in the first, the percentage of injury arising from treatment being apparent in every case. The injury appears to increase as the strength of the solution was increased.

Third trial.—The third trial was largely a duplicate of the second. The same varieties were used and the treatment was the same. Omitting tabulated data the results are as follows:

The untreated seed germinated 75 4–10 per cent.

The treated seed, 1 pint to 50 gal., 68 per cent.

The treated seed, 1 pint to 40 gal., 65½ per cent.

The treated seed, 1 pint to 25 gal., 50½ per cent.

The treated seed, 1 pint to 10 gal., 15 4–10 per cent.

SUMMARY.

1. Seed oats were injured by soaking in a solution composed of 2½ parts of formaldehyde in 1,000 parts of water.

2. The injury varied in the different experiments from 6.4 per cent. to 17.4 per cent.

3. When stronger solutions were used the percentage of injury increased in direct proportion to the strength of the solution used.

4. The tests were conducted under ordinary field conditions.

Conclusions.—Treating seed oats with formaldehyde to prevent oat smut has been successfully practiced for a number of years. The vigorous growth and abundant crops of smut-free

oats obtained where the treatment has been carefully practiced furnishes abundant testimony as to the value of the treatment and if generally adopted by farmers would undoubtedly lead to great benefits.

The writer can see no reason for abandoning the work even in the light of the above cited experiments. No question has been raised as to the value of the treatment in preventing smut. The experiments have been confined wholly to the influence of formaldehyde on the viability of the seed. While the successful issue of many carefully conducted experiments and the experience of farmers appear to be in contradiction to the above results, a careful consideration of some of the factors involved in the culture of oats will show that the two lines of experiment are not widely at variance. It is probable that the seeds that were destroyed as a result of the treatment were those of low vitality leaving the strongest to develop a crop. Again, the yield of oats from any given area will be, to a certain limit, in inverse ratio to the number of plants growing on that area. This limit of profitable planting is undetermined. Do not farmers as a rule sow too much seed oats per acre?

This question and others connected with the formaldehyde treatment remain as the subject of future investigations.

REPORT OF AN EXPERIMENT IN PLANTING CLOVER AT DIFFERENT DEPTHS.

F. CRANEFIELD.

Believing that any facts concerning the sowing of clover seed or a determination of the conditions most favorable to its germination would be of interest, the following experiments in planting at different depths were conducted during the past season.

First trial.—In preparation for the seeding, a space, 4 x 16 ft., in a garden plot of rich soil enclosed by six inch boards sunk four inches in the ground was divided into 21 equal spaces. After thorough preparation of the soil 1,000 clover seeds were sowed in rows on the surface of each of seven of these beds. The seeds in the various beds were then covered with finely sifted soil as follows: Two inches, 1 inch, ¾ inch, ½ inch, ¼ inch and ⅛ inch deep. In the remaining bed the seeds were pressed slightly into the soil but were not covered. In all cases the soil was sifted loosely over the seeds and not afterwards compacted.

The germination* of the seeds in the different plats was noted at the end of five, ten and twenty days. The results are given in the following table.

*The word *germination*, as commonly employed with reference to seeds, indicates the bursting of the seed case by the enclosed plantlet. It is used here in a wider sense and as a convenient term to express the appearance of the plant above ground.

Table showing the number of germinatings at the end of 5, 10 and 20 days of seeds planted at varying depths from 1/8 inch to 2 inches.

	Seeds not covered.	Seeds covered 1/8 inch.	Seeds covered 1/4 inch.	Seeds covered 1/2 inch.	Seeds covered 3/4 inch.	Seeds covered 1 inch.	Seeds covered 2 inches.
No. of germinat'ns after 5 days.....	0	0	10	370	218	50	0
After 10 days......	63	613	630	630	599	583	154
After 20 days......	269	691	765	669	551	593	173

An examination of the data recorded here shows that the highest percentage of germination occurred in the 1/4 inch lot and the next highest in the 1/8 inch lot, but the germinations in both of these lots during the first period of five days amounted to less than one per cent. of the total numbers of germinations while in the 1/2 inch and 3/4 inch lots, nearly 50 per cent. of the seeds germinated during the first period. The germination of 17 3--10 per cent. of the seeds when covered with two inches of soil was a surprising feature.

Second trial.—In this trial the fourteen remaining plats were divided into two groups of seven each and planted as in the first experiment except that an equal amount of seed by weight, 1–16 ounce, was sowed on each plat instead of a definite number of seeds.

Below is given the number of germinations in the different plats for 5, 10 and 20 day periods.

Table showing number of germinations after 5, 10 and 20 days of clover seeds planted at varying depths.

	GROUP A.			GROUP B.		
	No. of ger. after 5 days.	No. of ger after 10 days.	No. of ger. after 20 days.	No. of ger after 5 days.	No. of ger. after 10 days.	No. of ger after 10 days.
Seeds not covered......... ..	0	104	331	0	103	361
Seeds covered 1/8 inch.	0	641	823	0	423	767
Seeds covered 1/4 inch	0	635	852	10	529	833
Seeds covered 1/2 inch	208	620	758	370	709	740
Seeds covered 3/4 inch	229	586	654	218	661	684
Seeds covered 1 inch	250	632	607	50	523	508
Seeds covered 2 inch	0	267	338	0	112	262

The results in this case are similar to those obtained in the first experiment. The earliest germination occurred in the plats covered 1/2 and 3/4 inches deep, and the highest percentage of germination in the 1/8 inch and 1/4 inch plats.

Third trial.—The conduct of this trial was the same as that of the two preceding ones regarding the preparation of the ground, amount of seed, depth of covering, etc., the only difference being in the manner of covering the seeds. In the trials previously described fine soil was loosely sifted over the seeds to the required depth without compacting; owing to subsequent settling the actual covering when compacted was probably less than one-half of that indicated in the description of the experiments. In this trial the soil was firmly and evenly compacted over all the seeds to the required depth.

One-sixteenth of an ounce of seed was sowed in each of 21 plats. The number of plants which appeared was noted at 10 and at 15 days after planting. The record appears below.

Table showing the number of germinations from 1/16 oz. of seed after 10 and 15 days when planted at varying depths.

	GROUP A.		GROUP B.		GROUP C.	
	No. of ger. after 10 days.	No. of ger. after 15 days.	No. of ger. after 10 days.	No. of ger. after 15 days.	No. of ger. after 10 days.	No. of ger. after 15 days.
Seeds not covered	56	387	45	476	72	489
Seeds covered 1/8 inch	841	888	620	739	573	750
Seeds covered 1/4 inch	890	913	517	741	463	729
Seeds covered 1/2 inch	763	834	274	724	206	652
Seeds covered 3/4 inch	583	649	50	545	75	470
Seeds covered 1 inch	428	553	9	200	23	263
Seeds covered 2 inches	10	50	0	61	0	127

The 1/8 inch and 1/4 inch plats lead in this trial both in the earliness as well as in the total number of germinations. The number of germinations decreases very rapidly as the depth of planting is increased, the number in the two-inch plat being so few that the seeding would be considered a failure if encountered in farm practice. When the plants in these plats were

35 days old, an average specimen from each bed was removed by washing out the roots with a fine stream of water and the plants photographed .Fig. 37 is a reproduction of this photograph.

It will be seen that the plants from the deep planted seeds developed a longer root system than the ones planted nearer the surface.

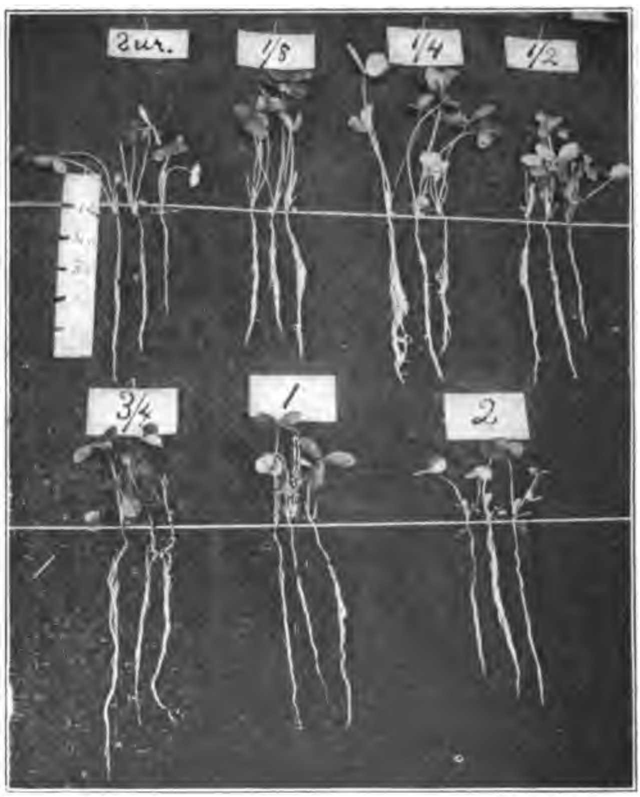

FIG. 37.—Showing specimen plants from each of the 7 plats described in third trial.

The most vigorous plants and the ones having the best root system were invariably found in the ¼, ½ and ¾ inch plats. The "surface" plants were always smaller than those in any of the other plats.

Fourth trial.—In this trial only 300 seeds were planted in each plat, all other conditions being the same as in

the third trial. The first plants appeared in the 1/4 inch plat, this plat also yielding the highest number of germinations. The plants in the different beds were counted each day for 10 days following the first germination. The final count showed the following results.

Not covered 88, 1/8 inch 141, 1/4 inch 248, 1/2 inch 225, 3/4 inch 214, 1 inch 175, 2 inches 0.

When expressed in percentages the results appear as follows:

Not covered 29 3-10 per cent., 1/8 inch 47 per cent., 1/4 inch 82 6-10 per cent., 1/2 inch 75 per cent., 3/4 inch 71 3-10 per cent., 1 inch 58 3-10 per cent., 2 inches 0.

The results approach closely those found in the previous experiments, the 1/4 inch and 1/2 inch plats showing the earliest as well as the highest percentage of germination. Fig. 38 shows these plats as they appeared 35 days after planting.

Weather conditions.—During the progress of the first and second trials the weather was dry; immediately following the sowing of the seed in the third trial a heavy and beating rain occurred, followed by several showers during the continuance of the experiment.

Size of clover seed.—The seeds of the common red clover, *Trifolium pratense*, are kidney-shaped. The approximate length of the seeds used in these experiments was 1-13 of an inch and the diameter 1-21 of an inch. While no arbitrary rule may be given concerning the best depth to plant seeds it is generally conceded that a depth equal to 3 to 4 times the diameter of the seed is the most favorable. Following this rule clover seed would be planted a trifle over 1/8 inch deep. This seems to be a very favorable depth as shown by the experiments.

FIG. 38.—Showing plats described in fourth trial 35 days after sowing seeds.

Table containing a tabular statement of the plots showing the earliest and highest percentage of germination in the different experiments.

	Depth of Covering.			
	First trial.	Second trial.	Third trial.	Fourth trial.
Plots showing earliest germination	½, ¾	½, ¾	⅛, ¼	¼, ⅛
Plots showing highest percentage of germination.....	⅛, ¼	⅛, ¼	⅛, ¼	¼, ⅛

SUMMARY.

1. The experiments described involved the planting of about 45,000 seeds.

2. The conditions for germination were in most of the cases more favorable than is usually encountered in farm practice.

3. Shallow planting between 1/8 and 3/4 inch was most favorable to rapid germination.

4. Shallow planting between 1/4 and 3/4 inch produced the highest percentage of germination in a majority of cases.

5. When the seeds were covered with one inch of compacted soil less than one-half of them germinated.

6. When covered with two inches of compacted soil less than one-fifth germinated.

ROAD CONSTRUCTION.

LESLIE H. ADAMS.

During the present summer we were enabled to inaugurate some improvements of a permanent nature at the College Farm that were greatly needed and had long been contemplated. Nearly a mile of macadam road has been constructed the present year, and since the interest in permanent road construction is increasing it was thought that the data obtained in our work may prove helpful. In considering the cost of constructing a stone road the local conditions prevailing form an important factor. If much grading or drainage is required to properly prepare the foundation, or if the stone must be hauled great distances, the cost of construction will be greatly increased.

However, the great improvements recently made in portable machinery for crushing rock, and the general availability of good road material in our state renders it possible for our farmers in many communities to no longer regard a stone road in front of their farms as a luxury but rather a necessity to enable them to keep pace with the changing conditions of rural life, for the coming of the telephone, electric suburban railway and stone roads are fore-runners of a new era on the old farm.

A view of the "Farm Drive" is given as it appeared at the completion of the work done upon it. (See Fig. 39.) It was formerly one of the worst stretches of roadway on the campus, and now besides being a thing of beauty, it is a joy and satisfaction forever. The total width of the track is twenty feet, a strip two feet wide on each edge of the track is composed of limestone screenings; this forms a shoulder for the crushed limestone, which covers the remaining sixteen feet of the track. The stone was

FIG. 39.—Road construction on the University farm. Building a macadam highway from farm buildings to Lake Mendota, and along its shore.

put on in two layers, the first or bottom one four inches deep and considerably coarser than the top layer, the bottom layer approximating the size of "egg" coal, and the top layer that of "nut" coal.

After the first layer of rock had been thoroughly compacted by means of the eight ton steam roller shown in the illustration, and partly bound with screenings, the second layer of finer stone was put on three inches deep. After this had been firmed as much as possible screenings were gradually applied and the roller kept going in order to facilitate the sifting down and filling up process, which operates to bind the stone in place. When no more open spaces could be found on the surface of the road and the stone was barely covered with screenings, the track was flooded with water by means of a sprinkling wagon and then rolled at once. After the road had become dry and hard it was opened for traffic. The two layers of stone, when packed, make a wearing body six inches deep. The cost of constructing one mile of this type of road is $3,000.00. This includes the grading necessary and culverts. The material had to be hauled about two miles. The crushed lime rock cost seventy-five cents per yard, and the screenings sixty-five cents per yard at the quarry. The expense of preparing the foundation for this road was not great, about five per cent of the total cost per mile. An important feature of a well constructed road is to provide a good high crowning surface so as to afford adequate and prompt shedding of water; the center of the road in the picture is six inches higher than its edge. A country highway should be provided with a double track, one constructed of stone and the other a well graded earth road, for light traffic. During the dry season of the year the earth road will be used in preference to the stone track and thus the latter will be relieved from considerable wear; the horses also will prefer the earth road when it is in good condition.

THE WISCONSIN FEEDING STUFF LAW.

(CHAPTER 377, LAWS OF 1901.)

Section 1. The term "concentrated commercial feeding stuffs," as used in this act, shall include linseed meals, cotton seed meals, pea meals, cocoanut meals, gluten meals, oil meals of all kinds, gluten feeds, maize feeds, starch feeds, sugar feeds, sucrene, hominy feeds, cerealine feeds, rice meals, oat feeds, corn and oat feeds, ground beef or fish scraps, mixed feeds of all kinds, also all condimental stock foods, patented and proprietary stock foods claimed to possess nutritive as well as medicinal properties, and all other materials intended for feeding to domestic animals; but shall not include hays and straws, the whole seeds nor the unmixed meals made directly from the entire grains of wheat, rye, barley, oats, Indian corn, buckwheat, dried brewers' grains, wet brewers' grains, malt sprouts, sorghum, and broom corn. Neither shall it include wheat, rye and buckwheat brans or middlings not mixed with other substances, but sold separately, as distinct articles of commerce, nor pure grains ground together.

Section 2. Every manufacturer, company or person who shall sell offer or expose for sale or for distribution in this state any concentrated commercial feeding stuff, used for feeding farm live stock, shall furnish with each car or other amount shipped in bulk and shall affix to every package of such feeding stuff in a conspicuous place on the outside thereof a plainly printed statement clearly and truly certifying the number of net pounds in the car or package sold or offered for sale, the name or trade mark under which the article is sold, the name of the manufacturer or shipper, the place of manufacture, the place of business and the percentages it contains of crude protein, allowing one percentum of nitrogen to equal six and one-fourth percentum of protein and of crude fat, both constituents to be determined by the methods prescribed by the Director of the Wisconsin Agricultural Experiment Station. Whenever any feeding stuff is sold at retail in bulk or in packages belonging to the purchaser, the agent or dealer, upon request of the purchaser shall furnish to him a certified copy of the statement named in this section.

Section 3. Before any manufacturer, company or person shall sell, offer or expose for sale in this state any concentrated commercial feeding stuffs, he or they shall for each and every feeding stuff bearing a distinguishing name or trade mark, file annually during the month of December with the Director of the Wisconsin Agricultural Experiment Station a certified copy of the statement specified in the preceding section, said certified copy to be accompanied, when the Director shall so request, by a sealed glass jar or bottle containing at least one pound of the feeding stuff to be sold or offered for sale, and the company or person furnishing the said sample shall also submit a satisfactory affidavit that said sample corresponds within reasonable limits to the feeding stuff which it represents in the percentage of protein and fat which it contains.

Section 4. Each manufacturer, importer, agent or seller of any concentrated commercial feeding stuffs shall pay annually to the Director of the Wisconsin Agricultural Experiment Station a license fee of twenty-five dollars. Whenever a manufacturer, importer, agent or seller of concentrated commercial feeding stuffs desires at any time to sell such material and has not paid the license fee therefor in the preceding month of December, as required by this section, he shall pay the license fee prescribed herein before making any such sale. The

license fees received by such Director pursuant to the provisions of this section shall be paid into the treasury of the university and shall constitute a special fund from which to defray the expenses incurred in making the inspections and analyses required by this act and enforcing the provisions thereof, and he shall report annually to the regents of the University of Wisconsin the amount received and the expense incurred for salaries, laboratory expenses, chemical supplies, traveling expenses, printing and other necessary matters. Whenever the manufacturer, importer or shipper of concentrated commercial feeding stuffs shall have filed the statement required by section two of this act and paid the license fees as prescribed in this section, no agent or seller of such manufacturer, importer or shipper shall be required to file such statement or pay such fee.

Section 5. The Director of the Wisconsin Agricultural Experiment Station shall annually analyze or cause to be analyzed at least one sample to be taken in the manner hereinafter prescribed, of every concentrated commercial feeding stuff sold or offered for sale under the provisions of this act. Said director shall cause a sample to be taken, not exceeding two pounds in weight, for said analysis, from any lot or package of such commercial feeding stuff which may be in the possession of any manufacturer, importer, agent or dealer in this state, but said sample shall be drawn in the presence of the parties in interest or their representatives, and taken from a parcel or a number of packages which shall not be less than ten percentum of the whole lot sampled, and shall be thoroughly mixed, and then divided into equal samples, and placed in glass vessels, and carefully sealed and a label placed on each, stating the name of the party from whose stock the sample was drawn and the time and place of drawing, and said label shall also be signed by the person taking the sample, and by the party or parties in interest or their representative at the drawing and sealing of said samples; one of said duplicate samples shall be retained by the director and the other by the party whose stock was sampled; and the sample or samples retained by the director shall be for comparison with the certified statement named in section three of this act. The result of the analyses of the sample or samples so procured, together with such additional information as circumstances advise, shall be published in reports or bulletins from time to time.

Section 6. Any manufacturer, importer or person who shall sell, offer or expose for sale or distribution in this state any concentrated commercial feeding stuff, without complying with the requirements of this act, or any feeding stuff which contains substantially a smaller percentage of constituents than are certified to be contained, shall, on conviction in a court of competent jurisdiction, be fined not less than twenty-five nor more than one hundred dollars for the first offense, and not more than two hundred dollars for each subsequent offense.

Section 7. Any person who shall adulterate any kind of meal or ground grain or other feeding stuff with milling or manufacturing offals, or any other substance whatever, for the purpose of sale, unless the true composition, mixture or adulteration thereof is plainly marked or indicated upon the package containing the same or in which it is offered for sale; or any person who sells, or offers for sale any meal, ground grain or other feeding stuff which has been so adulterated, unless the true composition, mixture or adulteration is plainly marked or indicated upon the package containing the same, or in which it is offered for sale, shall be fined not less than twenty-five or more than one hundred dollars for each offense.

Section 8. Whenever the director aforesaid becomes cognizant of the violation of any of the provisions of this act, he shall report such violations to the dairy and food commissioner, and said commissioner shall prosecute the party or parties thus reported; but it shall be the duty of said commissioner upon thus ascertaining any violation of sections two, three or four of this act, to forthwith notify the manu-

facturer, importer or dealer in writing and give him not less than thirty days thereafter in which to comply with the requirements of this act, but there shall be no prosecution in relation to the quality of any concentrated commercial feeding stuff if the same shall be found substantially equivalent to the certified statement named in section two of this act.

Section 9. This act shall take effect July 1st, nineteen hundred and one.

THE WISCONSIN FERTILIZER LAW.

[Sections 1494c, 1494d and 1494e, Wisconsin Statutes of 1898.]

SECTION 1494c. Every person who shall, in this state, sell or expose for sale any commercial fertilizer or any material used for fertilizing purposes, the price of which exceeds ten dollars per ton, shall affix to every package of such fertilizer or material, in a conspicuous place on the outside thereof, a plainly printed statement clearly and truly certifying the number of net pounds therein, name or trade-mark under which the article is sold, name of the manufacturer or shipper, place of manufacture, place of business of the manufacturer and of the following fertilizing constituents, namely: The percentage of nitrogen in an available form, of potash soluble in water and of available phosphoric acid, soluble and reverted, as well as total phosphoric acid. Every such person shall also file with the director of the agricultural experiment station of the university of Wisconsin, in the month of December in each year, a certified copy of such statement for every such fertilizer or material bearing a distinguishing brand or trade-mark and which he sells or exposes for sale, which copy shall, when required by such director, be accompanied by a sealed glass jar or bottle containing at least one pound of such fertilizer or material, and an affidavit that such sample corresponds, within reasonable limits, to the fertilizer or material which it represents in the percentage of the aforesaid constituents, which affidavit shall apply to the remaining portion of the then calendar year. Additional brands of such fertilizer or material may be offered for sale during the year, provided samples and affidavits are so filed at least one month before they are offered, in which case an analysis fee of double the usual amount must be paid. A deposit of the sample of fertilizer shall be required by said director unless the person selling or offering for sale a fertilizer or material within this section shall certify that its composition for the succeeding year is to be the same as given in the last previously certified statement, in which case the furnishing of a sample shall be at the discretion of said director.

SECTION 1494*d*. Said director shall analyze or cause to be analyzed all such samples and publish the results of such analysis in a bulletin or report on or before the first day of the next succeeding April. Every manufacturer, importer, agent or seller of any such fertilizer or material shall pay annually to said director for each brand thereof sold within this state the sum of twenty-five dollars, and upon doing so and complying with the other provisions of law shall receive from him a certificate of such compliance which shall be a license for the sale of each brand thereof within the state for the calendar year for which such fee is paid. All moneys received by said director pursuant to this section shall be paid into the treasury of said station. Any person who shall sell or expose for sale any commercial fertilizer or material used for fertilizing purposes which is within the provisions of the preceding section without complying with the foregoing provisions or which contains a substantially smaller percentage of fertilizing constituents than are indicated by the printed statement thereon shall be punished by a fine of one hundred dollars for the first offense and of two hundred dollars for each subsequent offense.

SECTION 1494*e*. Said director shall annually analyze or cause to be analyzed at least one sample of every fertilizer or material used for fertilizing purposes sold or exposed for sale under the two preceding sections and enforce their provisions by prosecuting or causing the prosecution of every person who shall violate them. He may in person or by deputy, on tendering the value thereof, take a sample, not exceeding two pounds, for said analysis from any lot or package of fertilizer or any material used for fertilizing

purposes which may be in the possession of any manufacturer, importer agent or dealer in this state; said sample shall be drawn in the presence of the person from whom taken or his representatives, be taken from a parcel or a number of packages which shall not be less than ten per centum of the whole lot sampled, be thoroughly mixed and divided into two equal samples, placed in glass vessels and carefully sealed and a label placed on each, stating the name or brand of the fertilizer or material sampled, the name of the party from whose stock the sample was drawn, the time and place of such taking; said label shall be signed by the director or his deputy and such person or his representative at the drawing and sealing of said samples; one of said duplicate samples shall be retained by the director and the other by the party whose stock was sampled; the sample retained by the director shall be for comparison with the certified statement named in section 1494c. The result of the analysis of the sample or samples so procured shall be reported to the person requesting the analysis and be published in a report or bulletin to be issued within a reasonable time.

EXCHANGES.

This Station takes pride in the fact that it has on file an almost complete list of the leading agricultural papers in the United States, besides many from foreign countries, and some not strictly treating of agriculture. These papers come to the Station in exchange for its reports and bulletins. While of the highest value to those connected with the Station as the expression of agricultural experience and sentiment, they are placed where they can be read and referred to by our agricultural students, and others of the University, as well as by visitors. Any one desiring sample copies of these papers can as a rule secure them upon application to the publishers, at the addresses given.

FOREIGN EXCHANGES.

Agricultural Gazette of New South Wales, Sydney, Australia.
Agricultural Journal, Cape Town, South Africa.
Analyst, London, England.
Australian Garden & Field, Adelaide, Australia.
Bulletin de la Agriculture, Bruxelles, Belgium.
Bulletin des Seances de la Societe Nationale d' Agriculture de France, Paris, France.
Chronique Agricole du Canton du Vaud, Lausanne, Switzerland.
Co-operative Farmer and Maritime Dairyman, Sussex, N. B.
Extrait des Travaux de la Soc. Centr. d'Agr. de la Seine Inf., **Rouen, France.**
Farm and Dairy, Sydney, N. S. W.
Farmer's Advocate, London, Ontario.
Farming, Toronto, Canada.
Farming World, Toronto, Canada.
Field, London, England.
Hochschule Nachrichten, Berlin, Germany.
Irish Farming World, Dublin, Ireland.

Journal für Landwirtschaft, Berlin, Germany.

Journal of Agriculture and Industry of South Australia, Adelaide, Australia.

Journal of the Bath and West of England Society, Bath, Eng.

Journal of the British Dairy Farmers' Ass'n, London, England.

Journal of the Council of Agriculture, Hobart, Tasmania.

Journal of the Department of Agriculture of West Australia, Perth, West Australia.

Journal of Royal Agricultural Society of England, London, England.

Kgl. Landtbruks-Akademiens Handlingar och Tidskrift, Stockholm, Sweden.

L'Agricultura Moderna, Milan, Italy.

Landbouwgalm, Kortrijk, Belgium.

Landwirtschaftliche Wochenblatt f. Schlesw.-Holstein, Kiel, Germany.

Le Messager Agricole, Montpelier, France.

L'Industrie Laitiere, Paris, France.

Live Stock Journal, London, England.

Milch Zeitung, Leipzig, Germany.

Mittheilungen des Milchw. Vereins im Allgäu, Memmingen, Germany.

New Zealand Dairyman, Wellington, N. Z.

North British Agriculturist, Edinburgh, Scotland.

North West Farmer, Winnipeg, Manitoba, Canada.

Tidsskrift for det norske Landbrug, Christiania, Norway.

Tidsskrift for Landökonomi, Copenhagen, Denmark.

Ugeskrift for Landmänd, Copenhagen, Denmark.

Weekly Times, Melbourne, Australia.

Zeitschrift des Landw. Vereins in Bayern, Munich, Germany.

DOMESTIC EXCHANGES.

Acker-und Gartenbau Zeitung, Milwaukee, Wis.

Agricultural Epitomist, Indianapolis, Ind.

Agricultural Experiments, Minneapolis, Minn.

American Agriculturist, New York City.

American Cultivator, Boston, Mass.

American Fertilizer, Philadelphia, Pa.

American Grange Bulletin, Cincinnati, O.

American Hay, Flour & Feed Journal, New York.

American Sheep Breeder and Wool Grower, Chicago, Ill.

American Swineherd, Chicago, Ill.

American Thresherman,* Madison, Wis.

Arboriculture, Chicago, Ill.

Beet Sugar Gazette, Chicago, Ill.

Blooded Stock on the Farm, Stock, Pa.

Breeders' Gazette, Chicago, Ill.

California Cultivator, Los Angeles, Cal.

*Received in Horticultural and Experiment Station Libraries.

Chicago Daily Drovers' Journal, Chicago, Ill.
Chicago Dairy Produce, Chicago, Ill.
Cold Storage, New York City.
Colman's Rural World, St. Louis, Mo.
Connecticut Farmer, Hartford, Conn.
Country Gentleman, Albany, N. Y.
Dairy & Creamery, Chicago, Ill.
Dairy World, Chicago, Ill.
Drainage and Farm Journal, Indianapolis, Ind.
Elgin Dairy Report, Elgin, Ill.
Farm and Fireside, Springfield, Ohio.
Farm and Home, Springfield, Mass.
Farm Home, Springfield, Ill.
Farm Students' Review, St. Anthony Park, Minn.
Farmer, The, St. Paul, Minn.
Farmers' Guide, Huntington, Ind.
Farmers' Review,* Chicago, Ill.
Farmers' Sentinel, Milwaukee, Wis.
Farmers' Voice,* Chicago, Ill.
Farm, Field and Fireside, Chicago, Ill.
Farm Journal, Philadelphia, Pa.
Farm, Stock and Home, Minneapolis, Minn.
Field and Farm, Denver, Colo.
Florists' Exchange,* New York City.
Flour and Feed, Waukegan, Ill.
Geflügel Züchter, Wausau, Wis.
Green's Fruit Grower,* Rochester, N. Y.
Hoard's Dairyman, Ft. Atkinson, Wis.
Holstein-Friesian Register, Brattleboro, Vt.
Hospodar, Omaha, Neb.
Indiana Farmer, Indianapolis, Ind.
Iowa Homestead, Des Moines, Iowa.
Jersey Advocate and Dairyman, New York City.
Jersey Bulletin, Indianapolis, Ind.
Kansas Farmer, Topeka, Kas.
Live Stock Report, Chicago, Ill.
Louisiana Planter, New Orleans, La.
Minnesota Horticulturist. Minneapolis, Minn.
Mirror and Farmer, Manchester, N. H.
National Stockman, Pittsburgh, Pa.
National Wool Manufacturers Association Bulletin, Boston, Mass.
Nebraska Farmer, Omaha, Neb.
New England Farmer, Boston, Mass.
New England Homestead, Springfield, Mass.
New York Produce Review and American Creamery, New York City.
Northwestern Agriculturist, Minneapolis, Minn.
Ohio Farmer, Cleveland, Ohio.
Orange Judd Farmer,* Chicago, Ill.
Oregon Agriculturist, Portland, Ore.
Pacific Rural Press, San Francisco, Cal.
Practical Farmer, Philadelphia, Pa.
Prairie Farmer, Chicago, Ill.
Reliable Poultry Journal, Quicy, Ill.
Rural New-Yorker,* New York City.
Rural Spirit, Portland, Oregon.
Southern Farm Magazine, Baltimore, Md.

*Received in Horticultural and Experiment Station Libraries.

Southern Planter, Richmond, Va.
Strawberry Culturist,* Salisbury, Md.
Strawberry Specialist,* Kitrell, N. C.
Successful Farming, Des Moines, Ia.
Sugar Beet, Philadelphia, Pa.
The Fruitman, Mount Vernon, Ia.
The Ruralist, Salisbury, Md.
Tobacco Leaf, New York City.
Trade, Baltimore, Md.
Wallace's Farmer, Des Moines, Ia.
Weekly Call, San Francisco, Cal.
Western Creamery, San Francisco, Cal.
Western Fruit Grower, St. Joseph, Mo.
Western Rural, Chicago, Ill.
Wisconsin Agriculturist,* Racine, Wis.
Wisconsin Horticulturist,* Baraboo, Wis.
Wisconsin Sugar Beet, Menomonee Falls, Wis.
Wool Markets and Sheep, Chicago, Ill.

STATE PAPERS.

The Record, Algoma, Wis.
Amherst Advocate, Amherst, Wis.
Antigo Journal, Antigo, Wis.
Langlade County Special, Antigo, Wis.
Weekly News Item, Antigo, Wis.
The Eagle, Augusta, Wis.
The Times, Augusta, Wis.
Balsam Lake Ledger, Balsam Lake, Wis.
The Courant, Berlin, Wis.
Jackson County Journal, Black River Falls, Wis.
The Press, Blair, Wis.
Bloomington Record, Bloomington, Wis.
Brillion News, Brillion, Wis.
Independent, Brodhead, Wis.
Register, Brodhead, Wis.
Rock County Banner, Clinton, Wis.
Advocate, Cumberland, Wis.
The Record, Dale, Wis.
Green Lake County Reporter, Dartford, Wis.
Chronicle, Dodgeville, Wis.
Sun, Dodgeville, Wis.
The Leader, Eau Claire, Wis.
The Telegram, Eau Claire, Wis.
The Times-Review, Fennimore, Wis.
The Journal, Grantsburg, Wis.
The News, Hammond, Wis.
Weekly Press, Highland, Wis.
The Sentry, Hillsboro, Wis.
The Independent, Juneau, Wis.
The News, Knapp, Wis.
The Republican & Leader, La Crosse, Wis.
The Weekly Budget, Ladysmith.
Reporter, Lancaster, Wis.
Weekly Teller, Lancaster, Wis.
The Herald, Lake Geneva, Wis.
Lodi Valley News, Lodi, Wis.
The Eagle, Marinette, Wis.
The Medford Democrat, Medford, Wis.
Winnebago Anzeiger, Menasha, Wis.
Lincoln County Anzeiger, Merrill, Wis.
The Wisconsin Leader, Merrillan, Wis.

*Received in Horticultural and Experiment Station Libraries.

The Republican, Necedah, Wis.
Press, New London, Wis.
Republican, New London, Wis.
St. Croix Republican, New Richmond, Wis.
The Voice, New Richmond, Wis.
The Enterprise, Oconomowoc, Wis.
La Crosse County Record, Onalaska, Wis.
Observer, Oregon, Wis.
Enterprise, Palmyra, Wis.
Grant County Witness, Platteville, Wis.
Press, Poynette, Wis.
Union, Prairie du Chien, Wis.
Free Press, Reedsburg, Wis.
The Times, Reedsburg, Wis.
Rib Lake Herald, Rib Lake, Wis.
Prescott Tribune, Prescott, Wis.
The Chronotype, Rice Lake, Wis.
The Advance Press, Ripon, Wis.
The Telegram, Sheboygan, Wis.
Sheboygan County News, Sheboygan Falls, Wis.
Watchman, Shell Lake, Wis.
News, Shiocton, Wis.
Republican, Stanley, Wis.
St. Croix Valley Standard, St. Croix, Wis.
Door County Advocate, Sturgeon Bay, Wis.
Door County Democrat, Sturgeon Bay, Wis.
The Chronicle, Tigertown, Wis.
The Tomahawk, Tomahawk, Wis.
Journal, Tomah, Wis.
Herald, Trempealeau, Wis.
The Post, Waupaca, Wis.
Waupun Leader, Waupun, Wis.
Wonewoc Reporter, Wonewoc, Wis.

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From U. S. Sugar Refinery, Chicago, Ill., 625 lbs. Waukegan Gluten Feed.

From Wm. S. Myers, Director Nitrate of Soda Propaganda, New York City, 800 lbs. Nitrate of Soda, 100 lbs. Peruvian Guano, museum specimens of Nitrate of Soda and Caliche, one copy of "Views of Chilian Nitrate Works and Ports."

From German Kali Works, New York City, a set of 11 lantern slides of Stassfurt industries; 125 copies each of "Farmers' Guide", "Tobacco Culture" and "Fertilizer Experiments"; 25 copies each of "Plant Food", "Truck Farming" and "Cow Pea"; eleven museum samples of crude and refined potash salts.

From U. S. Department of Agriculture, Division of Chemistry, 20 lbs. Kleinwanzleben Nachzucht (from H. Bennecke & Sohn, Athensleben, Germany).

From Armour Fertilizer Works, Chicago, Ill., 11 specimens of fertilizer materials.

From Swift & Co., Fertilizer Department, Chicago, Ill., 200 lbs. of Swift's Pure Sugar Beet Grower.

From Chas. R. Lull, Milwaukee, Wis., 9 samples of different grades of wheat bran and wheat middlings.

From Wm. Douglas & Sons, Ltd., London, England, 1 copy Douglas Encyclopaedia.

From Ed. The Weekly Live Stock Report, Union Stock Yards, Chicago, 1 bound copy of the Weekly Live Stock Report for 1901.

From Henry Gannan, Lexington, Kentucky, 2 lantern slides.

From The Walker-Gordon Laboratory, Boston, Mass., 7 lantern slides.

From the Pasteur Vaccine Co., Ltd., Chicago, Ill., Blacklegine with instrument for injecting, Pasteur Anthrax Vaccine, Tetanus Antitoxine, Antistreptococcic serum.

From C. F. Dawson, Washington, D. C., Culture of B. tuberculosis.

From Miss A. L. Burdick, Madison, Wis., Culture of B. typhosus.

From V. H. Bassett, Baltimore, Md., Cultures of Bacteria.

From Parke, Davis & Co., Detroit, Mich., samples of Antidiphtheritic serum. Antitetanic serum, Antistreptococcic serum, Antitubercle serum,

Tuberculin, Mallein Erysipelas and Prodigiosus toxines, Aseptic vaccine, Blacklegoids, Blackleg-vaccine, Aseptic ergot.; also one large case containing specimens of Biological Products.

From Pabst Brewing Co., Milwaukee, two pints Montana Barley.

From L. D. Sherman, Eldon, Iowa, Sherman's Northern Prolific Cow Peas (one pint).

From Edward E. Evans, West Branch, Mich., 1 pk. each of New Era Cow Peas, Mich. Favorite Cow Peas, Red Rippen Cow Peas and Early Blackeye Cow Peas; two qts. each of Med. Early Black Soy beans, Ito San Soy beans, Early Brown Soy beans, Med. Early Green Soy beans, Early Yellow Soy beans, and Early Black Soy beans.

From Minn. Experiment Station, St. Anthony Park, Minn., 1 pk. each of Alfalfa seed, Minn. No. 25 Flax, Minn. No. 34 Flax; 4 qts. each of Minn. No. 550 Winter Wheat, Minn. No. 529 Winter Wheat, Minn. No. 2 Winter Rye, Minn. No. 1 Winter Rye and Minn. No. 32 Winter Rye.

From Iowa Exp. Station, Ames, Ia., one pk. Turkish Red Winter Wheat.

From Charles McCabe, Glencoe, Wis., one pk. Winter Wheat.

From U. S. Department of Agriculture, 2 qts. Winter Wheat.

From J. D. Clarke, Whitewater, Wis., 12 ears of corn.

From J. L. Reid, Delavan, Ill., ½ pt. Reid's Yellow Dent Corn, ½ pt. Parker's Mammoth Yellow Corn.

From F. B. Fargo & Co., Lake Mills, Wis., one 20 gal. Haugdahl Starter Can.

From Heller-Merz Co., Chicago, two 1 gal. cans Butter Color.

From Wagner Glass Works, New York, 12 Babcock Milk Test Bottles, new design; 1 Ohlsson Skim Milk Bottle, reading to one-tenth per cent fat, and 1 Wagner Skim Milk Test Bottle.

From Paul Oppermann & Co., Milwaukee, Wis., 1 Gallon Butter Color.

From D. H. Burrell & Co., Little Falls, N. Y., 1 Four Bottle Facile Jr. Babcock Milk Tester.

From O. Douglas, Boston, Mass., 12 Bottles Butter Culture.

From S. C. Keith, Jr., Charlestown, Mass., 18 Bottles Butter Culture.

From American Creamery Sup. Co., Waterloo, La., 100 Pounds Kno Rust Cleaning Powder; and 1 Package Germo Disinfectant.

From Preservaline Mfg. Co., Chicago, 1 Gallon Lakton Butter Color and 1 Gallon Lakton Cheese Color.

From M. H. Fairchild & Bro., Chicago, ¼ Doz. Pkgs. Brilliant Powdered Metal Polish.

From Fuller & Johnson, Madison, Wis., loan of 3 H. P. gasoline engine, and a number of tools for cultivation, for instructional purposes.

From John Luchsinger, Monroe, Wis. Package Apple cions.

From A. A. Hoyt, Watsonville, Cal. 2 Dozen "Propless Tree Prop."

From W. Atlee Burpee, Philadelphia, Pa., 17 pkts. flower seed, 28 pkts. vegetable seeds.

From Wm. Toole, Baraboo, Wis. 6 pkts. Pansy Seeds.

From The Tobacco Warehousing and Trading Co., Louisville, Ky. 1 package "Nicotocide" fumigating compound.

From Adler Color & Chemical Works, New York. 1 pkg. Agricultural Soap.

From C. G. Patten, Charles City, Iowa. 1 pkg. cions Wild Black Cherry.

From Stark Bros. Nurseries, Louisiana, Mo. 2 trees Poole's Pride Plum.

From Wm. F. Barkeley, Mount Pleasant, Pa. Four trees of seedling plums.

From Mr. S. W. Merrick, Janesville, Wis. 1 doz. Strawberry plants.

From J. I. Case Plow Works, Racine, Wis. Scatter Wire for Case-Keeler Seed Drill.

From O-At-Ka. Chemical Co., Munsford, N. Y. 5 lbs. "Black Death" Insecticide.

From Ernst Meyer, Norwalk, Wis. Specimen of Orange Rust Fungus.

From Irving Smith, Green Bay, Wis. Rooted Cuttings of Geraniums.

From Elmer Reeves, Waverly, Iowa. 100 Seedlings of Wild Black Cherry.

From Thomas Tullock, Rockford, Ill. Package Strawberry plants.

From Arch. McNeilage, Sec., Glasgow, Scotland. Clydesdales Stud Book, Vol. 24, 1902.

From John W. Groves, Sec., Springfield, Ill. American Short-Horn Herd Book, Vols. 7, 8, 9, 10, 49, 51, 52.

From J. E. Rawlence, Sec., Salisbury, England. Hampshire Down Flock Book, Vol. 13, 1902.

From John Risden, Jr., Sec., Wiveliscombe, Somerset, England. Davy's Devon Herd Book, Vol. 25, 1902.

From Ernest Prentice, Sec., 64 Oxford St., Ipswich, England. Suffolk Sheep Society Flock Book, Vol. 16, 1902; Large Black Pig Book, Vol. 3, 1902.

From John Parr, Sec., Wistow Grange, Leicester, England. National Pig Breeders' Assn. Herd Book, Vol. 18, 1902.

From W. M. McFadden, Sec., West Liberty, Iowa. American Poland-China Record, Vol. 26, 27, 28.

From Heber Humphrey, Sec., Shippon, Abingdon, England. British Berkshire Herd Book, Vol. 18.

From S. Hoxie, Sec., Yorkville, N. Y. Holstein-Friesian Advanced Registry, Vol. 13.

From Henry Wade, Sec., Toronto, Canada. Clydesdale Stud Book of Canada, Vol. 8, 9, 10, 11.

From American Trotting Register Association, 1608 Ellsworth Bldg., Chicago. American Trotting Register, Vol. 14, 15.

From W. Arthur Dew, Sec., Wellfield, Bangor, England. North Wales Black Cattle Herd Book, 7.

From John Risden, Jr., Sec., Wiveliscombe, Somerset, England. Devon Long-wool Sheep Flock book, Vol. 2.

From C. E. Stubbs, Sec., Fairfield, Iowa. National Register French Draft Horses, Vol. 7.

From William H. Caldwell, Sec., Peterboro, N. H. Guernsey Herd Register, Vols. 10, 11, 12.

From Joseph E. Wing, Sec., Mechanicsburg, Ohio. Continental Dorset Club Sheep Record, 2 copies of Vol. 2.

From Thomas H. Ensor, Sec., 54 South St., Dorchester, Dorset, England. Dorset Horn Sheep Flock Book, Vol. 11.

From Mortimer Levering, Sec., Springfield, Illinois. American Shropshire Sheep Record, Vol. 5 and 14; American Shetland Stud Book, 4.

From L. P. Sisson, Sec., Wheeling, West Virginia, Galloway Herd Book, 22.

From J. McLain Smith, Dayton, Ohio. Red Polled Herd Books, 12, 13, 14.

From H. B. Richards, Sec., Easton, Pa. Dutch Belted Cattle Herd Books, 5, 6.

From Chas. F. Martin, Sec., Denver, Colorado. Proceedings of the Fifth Annual Convention of the National Live Stock Association, 1902.

From C. R. Thomas, Sec., Chicago, Ill. American Hereford Record and Herd Book, Vol. 24.

FINANCIAL STATEMENT.

The Wisconsin Agricultural Experiment Station, in account with the United States appropriation.

1901-1902.	Dr.	Cr.
To receipts from treasurer of the United States as per appropriation for the year ending June 30th, 1902, under act of congress, approved March 2d, 1887	$15,000 00	....
By salaries	....	$8,908 33
By labor	....	2,368 16
By publications	....	....
By postage and stationery	....	115 65
By freight and express	....	85 73
By heat, light and water	....	35 00
By chemical supplies	....	654 97
By seeds, plants, and sundry supplies	....	1,118 15
By fertilizers	....	9 83
By feeding stuffs	....	213 70
By library	....	452 05
By tools, implements and machinery	....	125 00
By furniture and fixtures	....	....
By scientific apparatus	....	166 73
By live stock	....	360 00
By traveling expenses	....	312 75
By contingent expenses	....	2 00
By building and repairs	....	42 55
	$15,000 00	$15,000 00

We, the undersigned duly appointed auditors of the corporation, do hereby certify that we have examined the books and accounts of the Wisconsin Agricultural Experiment Station for the fiscal year ending June 30, 1902; that we have found the same well kept and classified as above, and that the receipts for the year from the treasurer of the United States are shown to have been $15,000, and the corresponding disbursements $15,000, for all of which proper vouchers are on file and have been by us examined and found correct.

And we further certify that the expenditures have been solely for the purposes set forth in the act of Congress approved March 2, 1887.

(Signed) B. J. STEVENS,
WILLIAM F. VILAS,
Executive Committee.

ATTEST:
E. F. RILEY,
Custodian.

INDEX.

NOTE.—Page numbers refer to pages of this report; subject matter in bulletins published during the fiscal year are also included in this index, reference to the same being made by giving the number of bulletin prefixed by B.